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Astronomy®

HDG 08070

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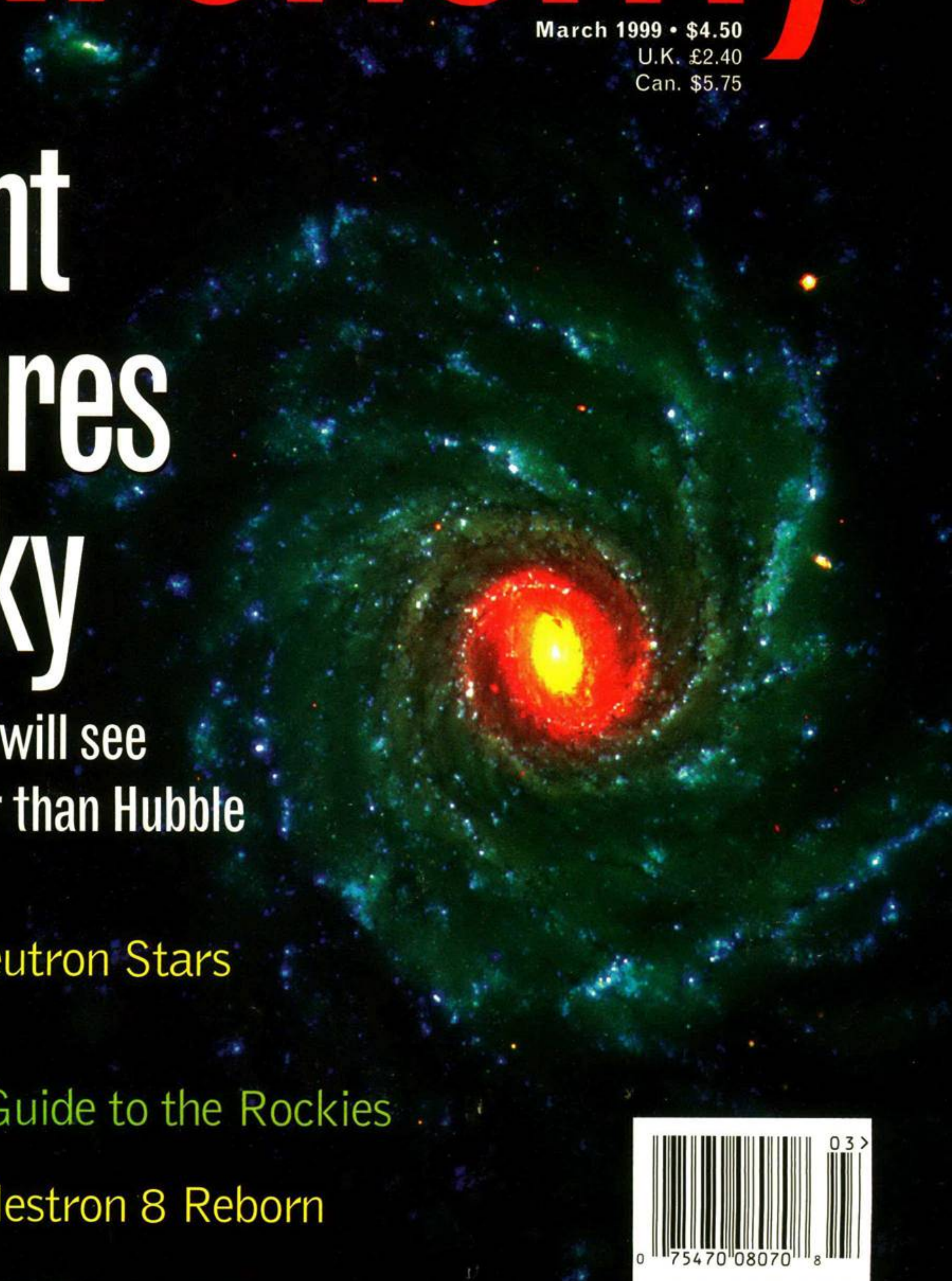
Can. $5.75



A Giant Captures the Sky

This telescope will see 50 times better than Hubble

Magnetars: Neutron Stars with Attitude

Astronomers' Guide to the Rockies

The Classic Celestron 8 Reborn

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Now, ETX pushbutton electronic control — for only *$595* complete!

Already the largest-selling modern telescope in the world, the Meade ETX has been re-engineered for 1999 to provide the very latest in microprocessor-controlled capability.

New Fork Mount Design with Standard-Equipment Dual-Axis Drive System: The ETX-90/EC's fork mount includes high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use the hand controller at any of four dual-axis speeds: 8x for image centering in the main telescope at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

Cordless Operation: The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base. Or use the optional 25 ft. auto cigarette lighter cord that plugs into the telescope's control panel.

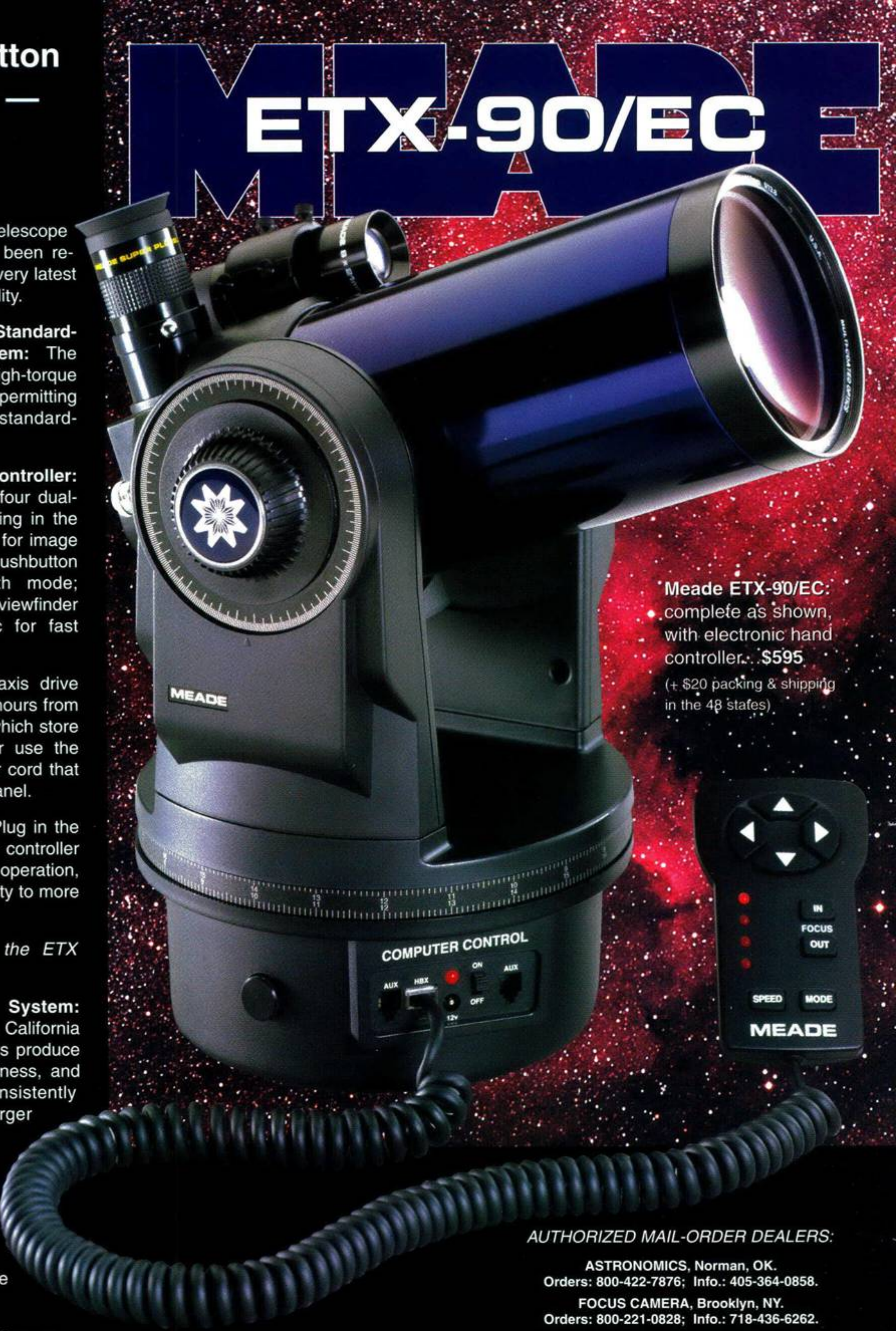
Optional Autostar™ Capability: Plug in the optional Meade Autostar computer controller *(see facing page)* for LX200-type operation, including automatic GO TO capability to more than 12,000 celestial objects.

Plus the features that created the ETX revolution:

Maksutov-Cassegrain Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of larger apertures.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

SPECIFICATIONS: ETX-90/EC Astro Telescope — Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. Net weight 9 lbs. — **$595** (+ $20 P & S).



Meade ETX-90/EC: complete as shown, with electronic hand controller. . **$595**

(+ $20 packing & shipping in the 48 states)

OPTIONAL SYSTEMS FOR ETX-90/EC

#497 Autostar Computer Controller	$149.00
#880 Equatorial Table Tripod	29.95
#883 Deluxe Full-Length Field Tripod	199.95
#825 8 x 25mm Right-Angle Viewfinder	49.95
#774 Hard Carry Case	99.95
#932 45° Erecting Prism	49.95
#64 Photo Adapter	34.95
#1244 Electric Focuser, plugs into control panel	119.95

AUTHORIZED MAIL-ORDER DEALERS:

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

Add the Meade Autostar™ hand controller to your ETX-90/EC for fully automatic GO TO object location

...only *$149!*

ETX AUTOSTAR
RA = 08:04.6
Dec = +36°38
MEADE
ENTER
MODE
GO TO
1
2
3
4
5
6
7
8
9
0
?

Plug the #497 Autostar Computer Controller into your ETX-90/EC and you're ready for an incredible array of LX200-type capabilities:

Automatic dual-axis GO TO function at 5°/sec to any of more than 12,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters — the best objects from the IC, NGC and Caldwell catalogs, as well as all 110 Messier objects); 900 stars (double stars, variable stars, SAO stars); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; 50 earth-orbiting satellites; plus user-defined objects and the centroids of all 88 constellations. Select any of these objects, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field.

Automatic GO TO function to *any* object of known R.A. and Dec.

Digital readouts of telescope position (continuously in R.A. and Dec.), menu options, glossary, and utility functions.

Precise sidereal-rate tracking in either altazimuth or equatorial modes. For altazimuth tracking, set the telescope on its drive base and perform a quick, easy alignment.

9-Speed Dual-Axis Operation: Pushbutton operation of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec.

RS-232 Serial Port: For operation of the telescope through a personal computer, using Meade Epoch 2000 sky software or programs of the user's own writing.

Plus: over 20 other menu options, including guided tours, major event menus, user-defined terrestrial objects, and much more.

The Meade #497 Autostar Computer Controller *(shown actual size)* plugs in directly to the control panel of the Meade ETX-90/EC and permits LX200-type automatic object location from a 12,000-object database, a database that includes virtually every astronomical object visible with the ETX-90/EC telescope. **$149.**

MEADE
COMPUTER CONTROL

(right) **Meade ETX-90/EC,** shown with optional #497 Autostar Computer Controller plugged into the telescope's control panel.

Write, call, or fax Meade Instruments for your free copy of the 100-page Meade General Catalog.

Prices shown are suggested U.S. mail-order retail prices.
Patents pending on ETX-90/EC and Autostar.

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March 1999 • Vol. 27, No. 3

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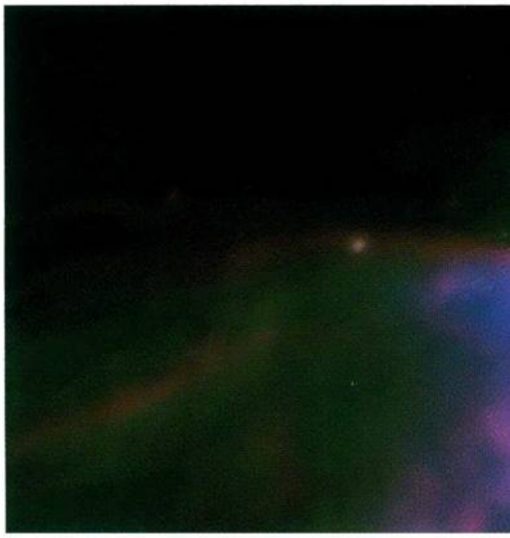

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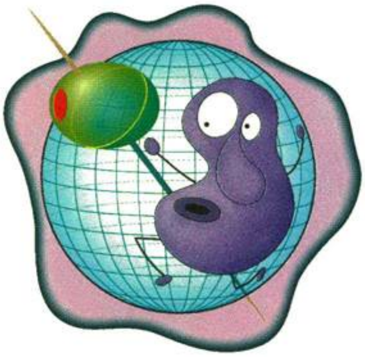

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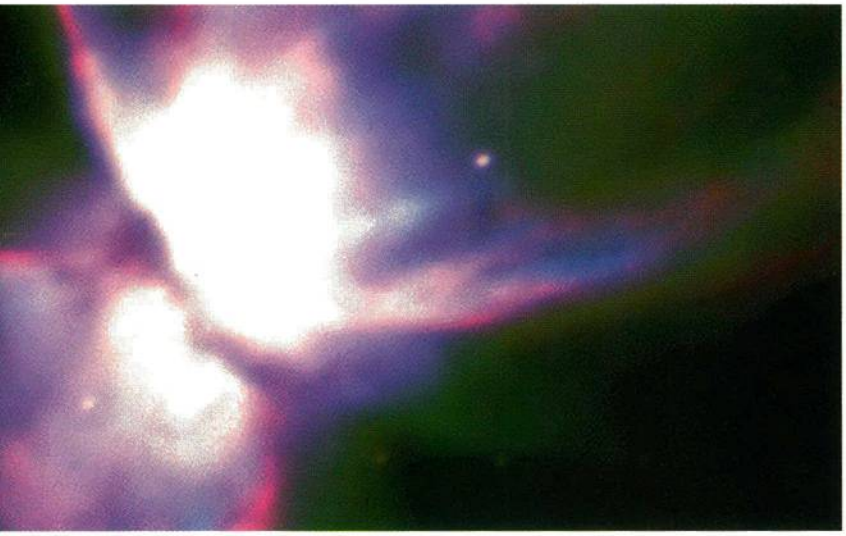

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BEHIND THE SCENES

BY BONNIE BILYEU GORDON

All the News that Fits

The Very Large Telescope, which will see first light in Chile as a four-part interferometer in about five years, is already bringing us great new views. One of its scopes is being tested as we go to press; the resulting photographs are very fine as you can see on page 58. Built and operated by the European Southern Observatory, the finished telescope promises images that are 50 times sharper than those being made right now by the Hubble Space Telescope. Once again technology is pushing astronomers closer to the edges of the universe and back in time toward the Big Bang.

Astronomy: Jim Forbes

Kelly Whitt

In much more local news, one Astronomy subscriber has become our copy editor. Kelly Whitt, who grew up in Sauk City, Wisconsin, is a graduate of the University of Wisconsin-Madison, where she majored in English and took courses in astronomy. Before coming to work for us, she lived in Nashville for three years where her husband, Jeremy, studied law.

Kelly believes she first became interested in the heavens as a child when her parents took her into the backyard on warm summer evenings to watch meteor showers. When she doesn't have her eyes on the sky, Kelly is busy reading the classics, creating word puzzles, traveling, and golfing. She lives in the Milwaukee area with her husband and her cat, Iago.

And, if you read mastheads at all, you may think we also have a new art director. But no. Carole Kramer, our art director for nearly three years now, married Ed Ross in October 1998 and is now Carole Ross. So please don't imagine we are about to embark on a new design (because they tend to come with new art directors). We love the one we have.

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ASTRONOMY (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Editorial phone: (414) 796-8776; advertising: (800) 558-1544; customer service: (800) 446-5489; subscriptions: (800) 446-5489, Monday through Friday, 8:30 A.M. to 5 P.M. CT, fax (414) 796-0126.
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Periodicals postage paid at Waukesha, WI, and additional offices. Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription price: 1 year $39.95, Canadian and foreign: 1 year $50, payable in U.S. funds (Canadian price includes GST). BN 12271 3209 RT. Canada Post Publication Agreement Number 545-775. Not responsible for unsolicited materials. POSTMASTER: Send address changes to ASTRONOMY, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187-1612.

MEADE 203/SC EMC
MEADE 203/SC EMC
Model 203SC/300:
8" f/10 Schmidt-Cassegrain Telescope
$795
(+ $65 packing and shipping in the 48 states)
(shown with optional #1702 Drive System)
Model 203SC/500:
8" f/10 Schmidt-Cassegrain Telescope
$895
(+ $65 P & S)
Model 102ACHR/300:
4" f/9 Achromatic Refracting Telescope
$595
(+ $55 P & S)
Model 102ACHR/500:
4" f/9 Achromatic Refracting Telescope
$695
(+ $55 P & S)
Meade
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MEADE

LXD 300

Now you can buy a Meade® 8" f/10 Schmidt-Cassegrain Telescope, complete with LXD 300 equatorial mount, rigid full-length aluminum tripod, and accessories for only $795! Or a Meade 4" f/9 Achromatic Refractor, complete, for only $595!

Choose either the Meade 203SC/300, with the exact same optical tube assembly as more expensive Meade 8" Schmidt-Cassegrains, or the Model 102ACHR/300 with its exquisite 4" Meade air-spaced achromatic lens. Both telescopes are equipped with the high-performance Meade LXD 300 equatorial mount with dual-axis aluminum worm gears.

SPECIFICATIONS: Models 203SC/300 and 102ACHR/300 — Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 300 equatorial mount with aluminum worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 50°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions. **8" — $795** (+ $65 P & S); **4" — $595** (+ $55 P & S); **#535 R.A. Motor Drive System...$99; #812 Polar Alignment Finder...$49.**

LXD 500

For even broader capability, use the Meade® high-precision LXD 500 equatorial mounting, 20% larger and with dual-axis bronze worm gears — the finest equatorial mounting available in its price class.

SPECIFICATIONS: Models 203SC/500 and 102ACHR/500— Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 500 equatorial mount with oversize bearings, high-precision bronze worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 60°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions **8" — $895** (+ $65 P & S); **4" — $695** (+ $55 P & S); **#1701 R.A. Motor Drive System** with 4-speed controller...**$145; #1702 Dual-Axis Drive System** with 4-speed controller...**$195; #812 Polar Alignment Finder...$49.**

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MEADE LX50

Advanced technology at the most affordable prices *ever.*

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*.

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

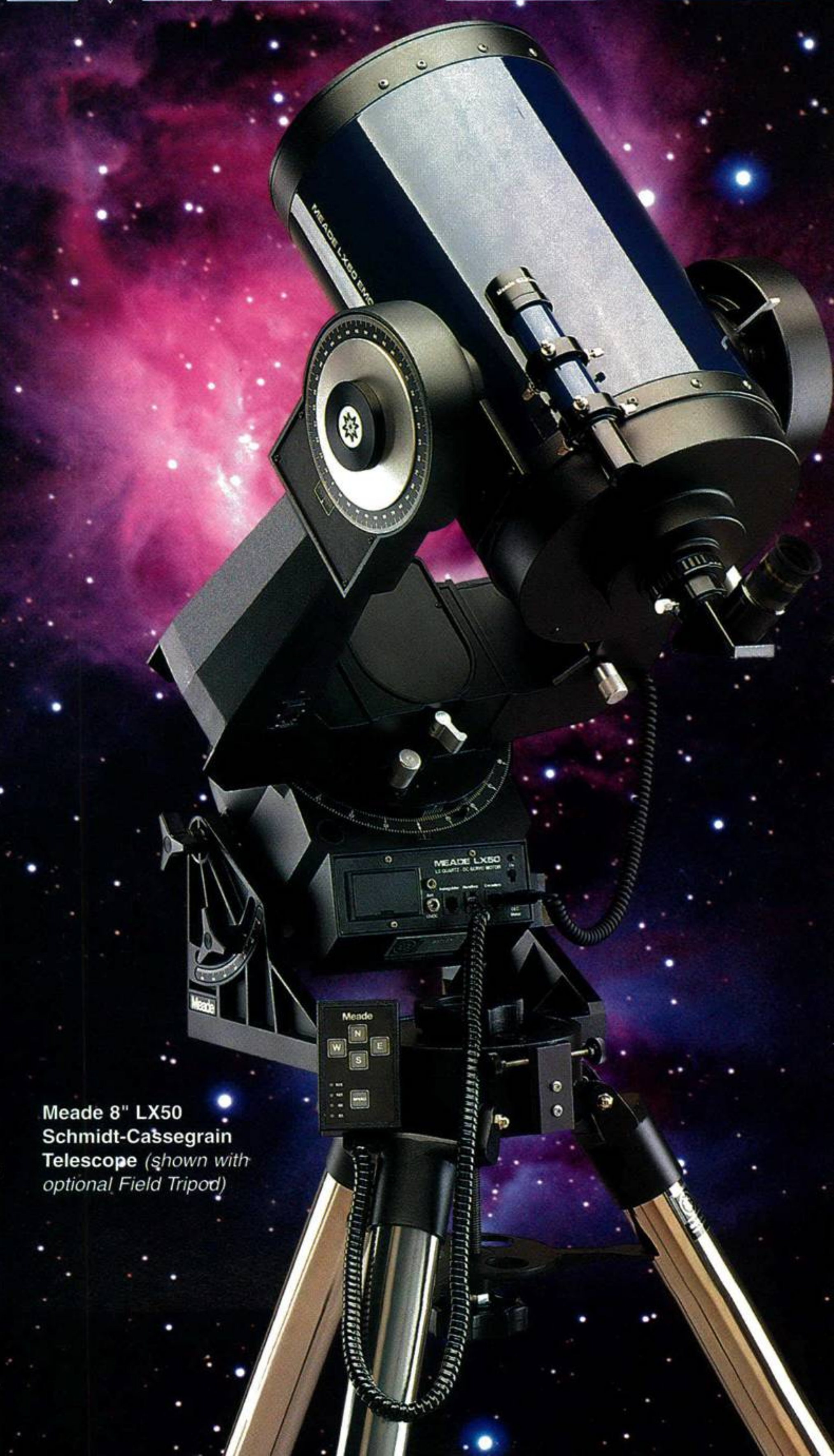
SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200

MEADE LX200 EMC
Meade
MEADE LX200
Meade
ENTER
MODE
GO TO
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Meade 10" LX200 Schmidt-Cassegrain Telescope

Prices shown are suggested U.S. national mail-order retail prices.

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

Write, call, or fax Meade Instruments for your free copy of the 100-page Meade General Catalog.

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MEADE STARFINDER DOBSONIANS

Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- 1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- 1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- 2 - **Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
ENTER
MODE
PREV
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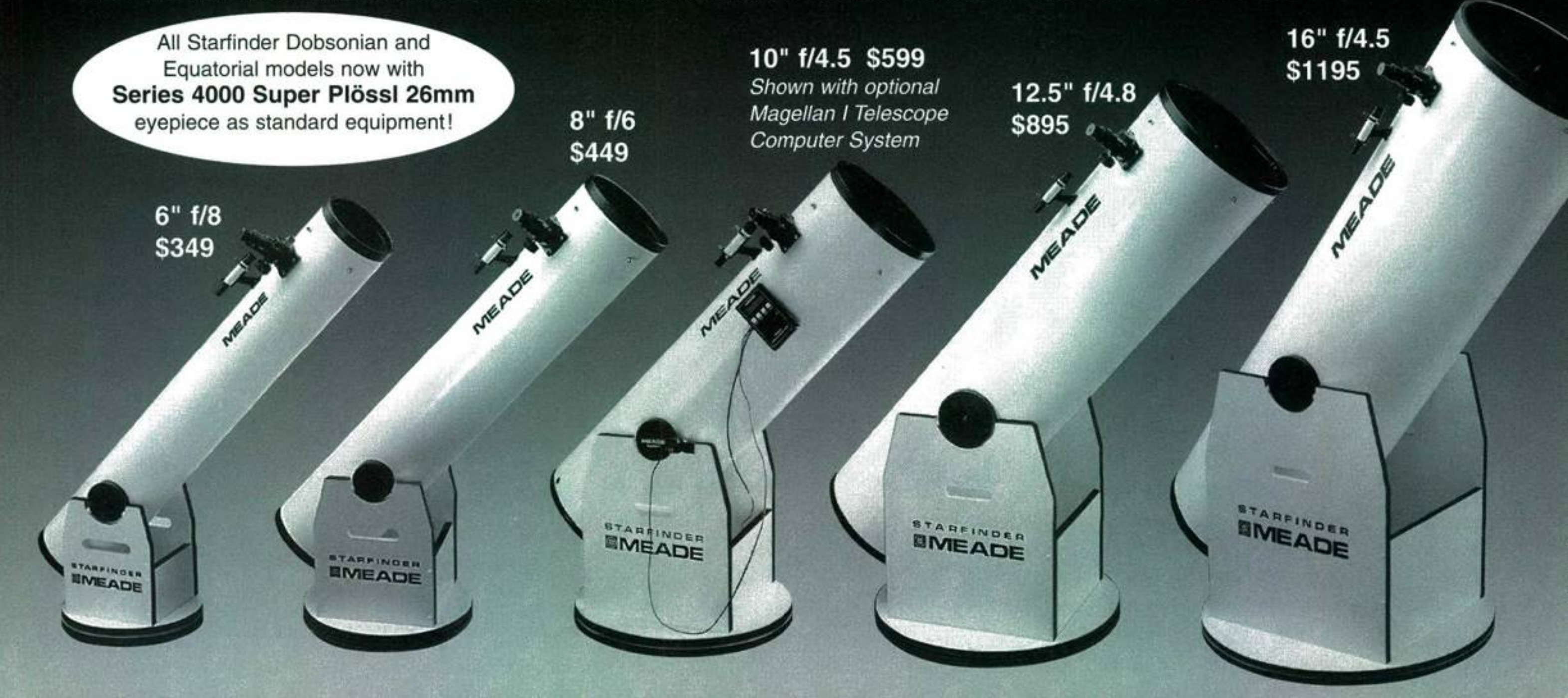
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***



All Starfinder Dobsonian and Equatorial models now with **Series 4000 Super Plössl 26mm** eyepiece as standard equipment!

6" f/8
$349

8" f/6
$449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12.5" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.

#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

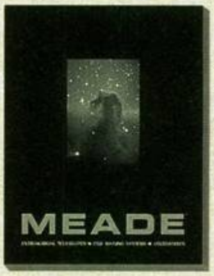
Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.

#2019: for (DC-powered) Starfinder Equatorial 16". . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*



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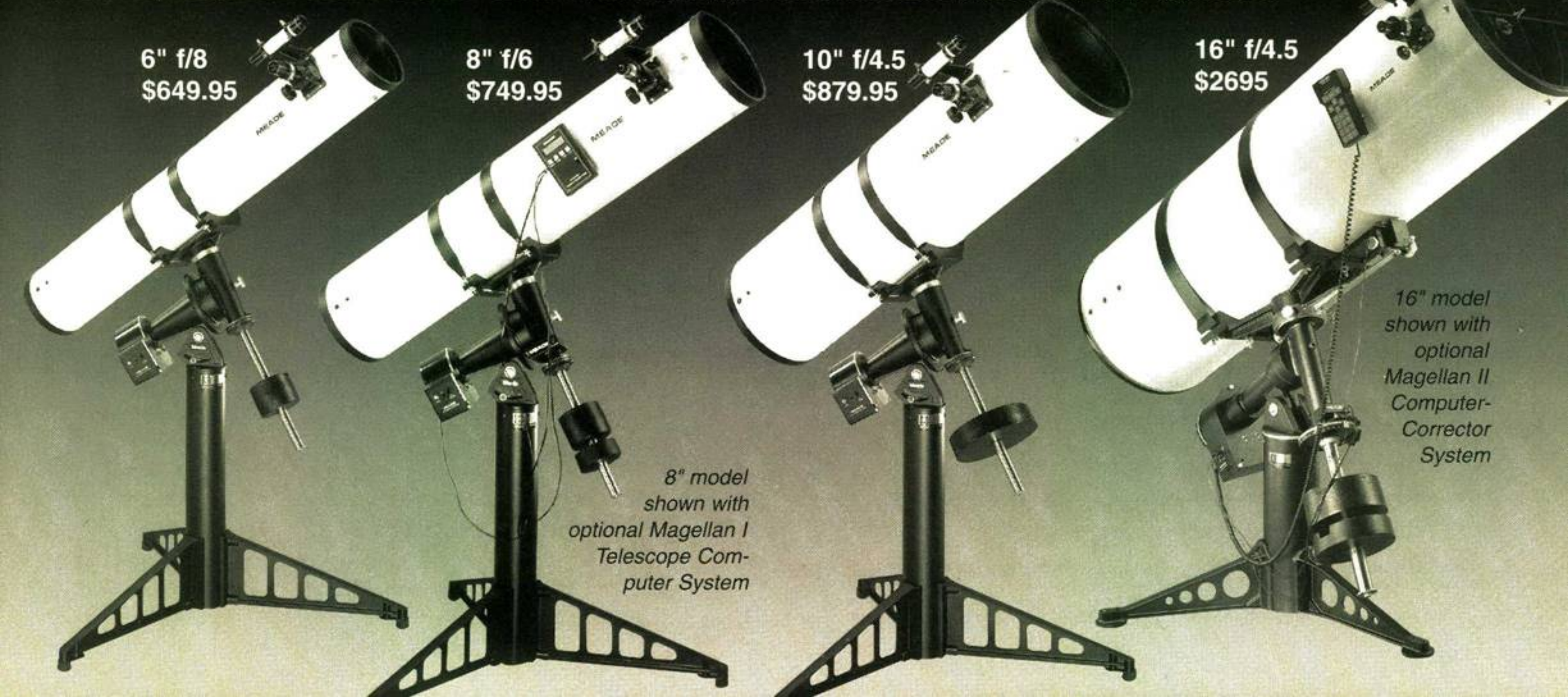
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



6" f/8 $649.95

8" f/6 $749.95

10" f/4.5 $879.95

16" f/4.5 $2695

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

8" LX10
8" LX10 DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	195.
Electric Declination Motor System for LX10	95.
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	375.

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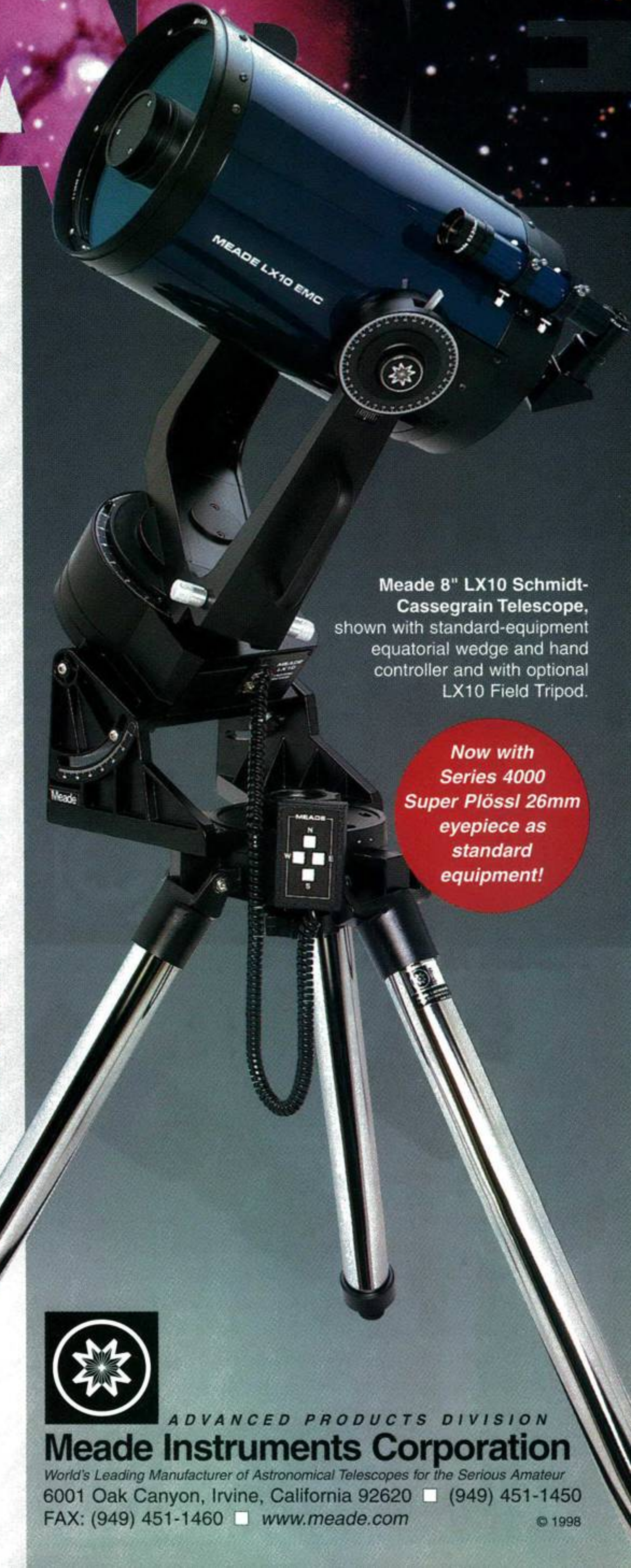

Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

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MEADE RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

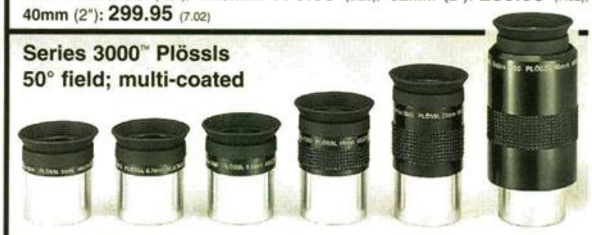
Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated



Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
New!
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

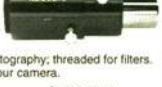
As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera. **$39.95** (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

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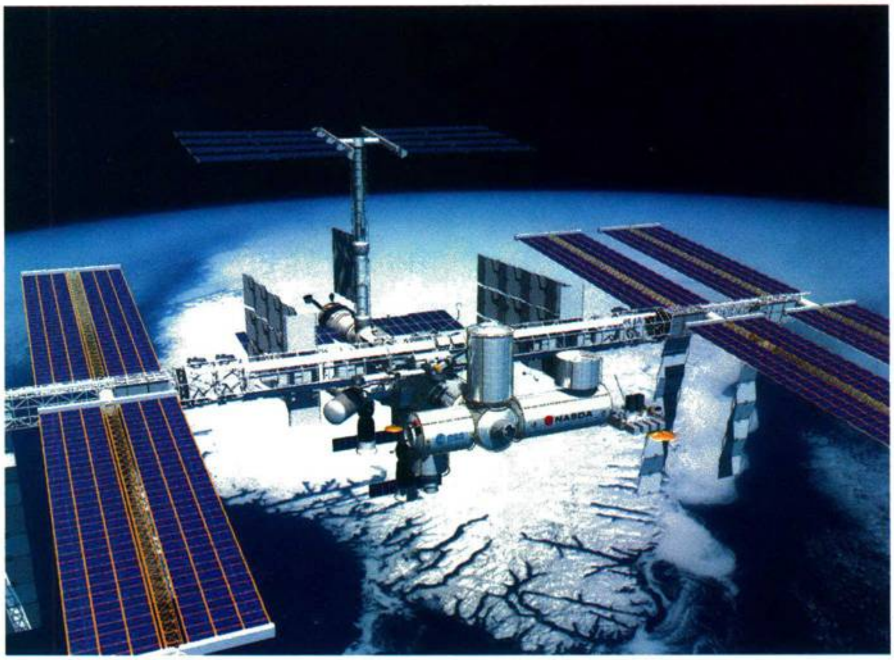
TALKING BACK
FROM OUR READERS

Glitch in Space-Station Spin?


NASA

By joining the first two pieces of the space station, astronauts have excited our imaginations.

I have enjoyed reading *Astronomy* for many years. As an astronomy educator at a local planetarium, I rely on the magazine to keep me up to date. However, Andrew Lawler's story on the International Space Station (ISS) in the December 1998 issue did not educate the public on this grand project. His story would have been better placed in the editorial section of a newspaper.

While the ISS may not achieve its goals on time and under budget, Lawler paints an unrealistically rosy picture for the unmanned space program. He seems to forget that the Hubble Space Telescope, Mars Observer, Galileo Spacecraft, and other robotic missions have encountered troubles. It may have been humans who caused Hubble's flaws, but humans repaired them.

The ISS is not merely a technological endeavor. It will require numerous countries and cultures with differing technologies and monetary systems to work together. Is this not what we have been working toward all along?

I support robotic exploration and manned exploration, whether to the bottom of the ocean or to the moon. Such exciting missions have captured the imaginations of all of us and encouraged students to pursue careers in science and technology. The ISS is sure to spin off new discoveries that would not have been made otherwise. — *Kristian Anderson, Des Moines, Iowa*

Aspiring Artist Inspired

I have wanted to write *Astronomy* for two years because I think your magazine has the best organization, story selection, layout, balance of editorial and advertising content, and writers. I was finally prompted to write by two articles in the December issue: "High Priests of Astronomy," and "When I Heard the Learn'd Theologians."

Religion and Science. This combination, a risk to tackle in any magazine, was handled extraordinarily well by *Astronomy*. I knew the Catholic Church accepted the Big Bang and Darwinian evolution, but I didn't know it owned and operated a $4-million telescope in Arizona.

The authors, David Grinspoon and Tony Ortega, inspired me so much that I am using their stories as references on a term paper for my World Religions class. I am a film major at the School of Visual Arts in New York City. My goal is to help eradicate ignorance of both science and religion in Hollywood. — *John D. Lombardi, New York, New York*

Photo Decision Impeached

I have been impressed for many years by *Astronomy's* focus on the science of astronomy and on professional and amateur astronomers themselves. The profile of "Black Hole Wrangler" Stephen Hawking in the December 1998 issue was interesting and timely because of what Hawking has done for years to provoke and challenge others to try to understand astrophysics. The story also was interesting because of its focus on how Hawking has accomplished intellectual feats while coping with Lou Gehrig's disease.

However, I was shocked by the utter lack of taste shown by *Astronomy* to publish a photograph of our philandering president, Bill Clinton, seated next to the accomplished scientist and his wife.

Clinton is relevant neither to Hawking nor to Astronomy's high caliber of reporting on astronomical topics. — *Julius J. Brecht, Anchorage, Alaska*

Beginner Solves Astroscan Problem

I am a 13-year-old beginning astronomer and I enjoyed reading "The Little Scope That Could," an equipment review by Glenn F. Chaple, Jr., in the May 1998 issue. While I like the overall ease of operating the Astroscan as Chaple did, the wide field of view made it difficult for me to

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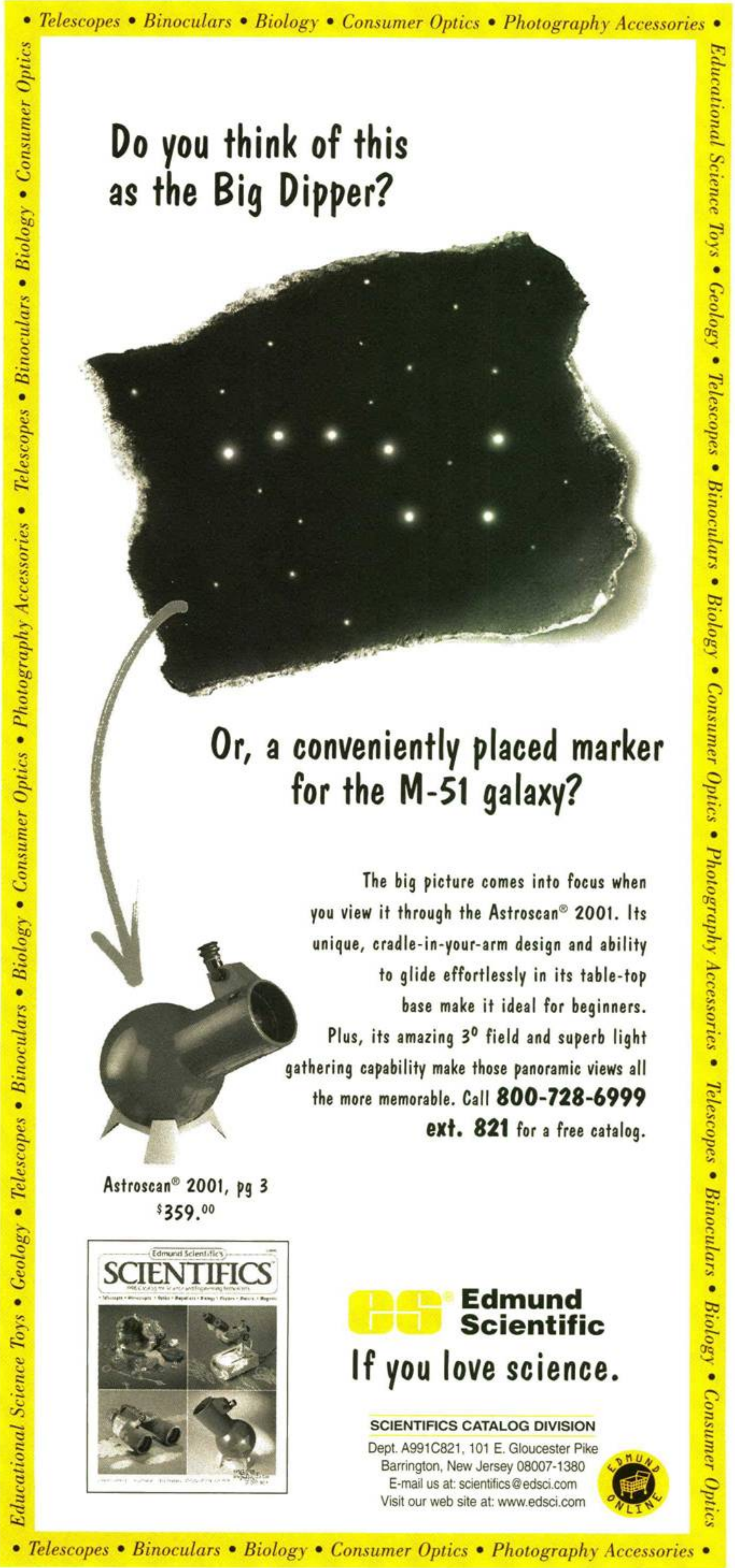

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center objects using the finder that came with the scope.

My father, Ruben, an experienced astronomer, was able to use the 1x sight-tube finder much better than I. He easily recognized the "faint fuzzies" at the edge of the fields. The sight tube was harder for me to align since it was so close to the telescope's body. I kept missing easy targets like the Double Cluster of Perseus, the Hercules Cluster, and other attractions.

We thought a different 1x finder would help. My dad had a Telrad, but when we used it, it was so heavy that its weight tipped the telescope on its side except when it was pointed straight up. Other 1x finders, such as the Celestron, Televue, and Orion, mounted so close to the telescope tube that the spherical base of the Astroscan got in the way. The Rigel quickfinder was a good alternative.

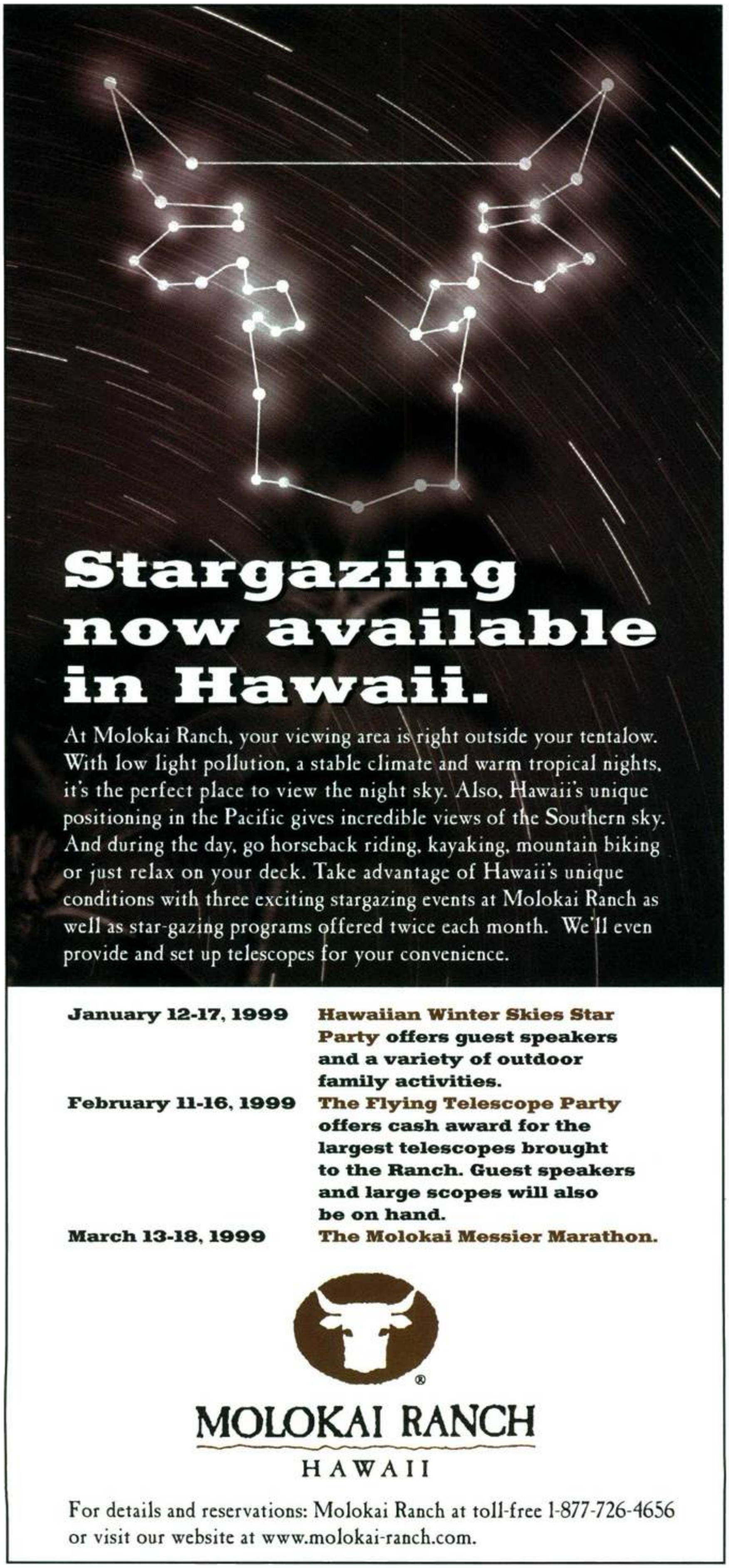
The Rigel is lightweight, and the Astroscan remained balanced in its cradle. The quickfinder was offset from the tube, and I was able to look through it while resting my cheek against the base of my scope.

Most importantly, the Rigel is easy to collimate precisely with the Astroscan each time I set up the scope for observing. Now I easily find any object that I can see with my eyes. Even though I am just a beginner, I have no problem centering the brighter planets, clusters, nebulae, and galaxies. — *Shelly Kier, Orange, Connecticut*

Traveling to Good Planets

The story "Good Planets Are Hard to Find" in the January issue did an outstanding job of outlining some of the difficulties we would encounter in our quest for other Earth-like planets. But writer Athena Andreadis fell for an old trap — allowing current technology to limit our imaginations about the future.

Our departure from Earth will be incremental. It will start with orbiting space stations followed by scientific way stations on the moon, Mars, or both. By the time technology has advanced to the point where colonization of Earth-like worlds is possible, many of the problems addressed by Andreadis — particularly food constraints and anxiety over inevitable isolation — will have been resolved.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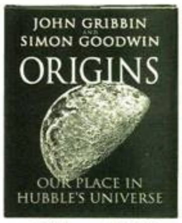
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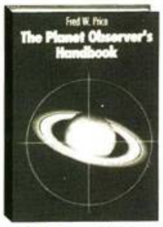
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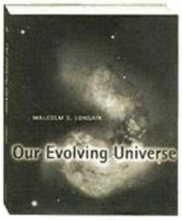
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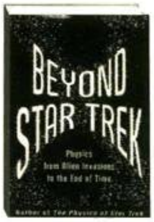
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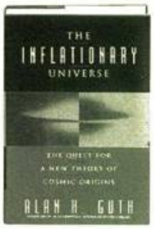
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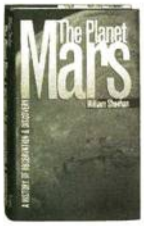
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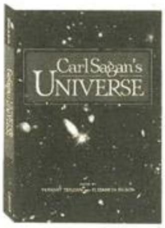
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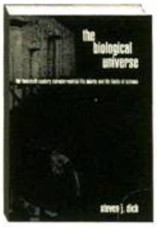
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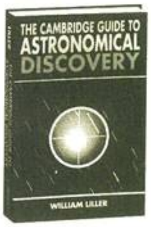
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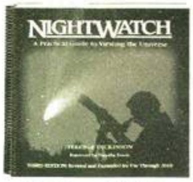
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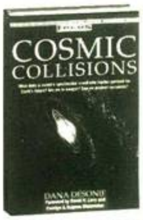
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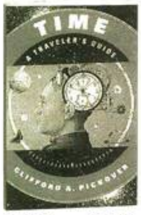
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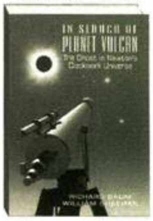
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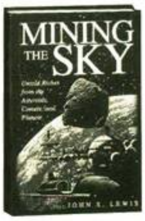
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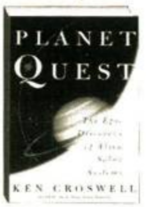
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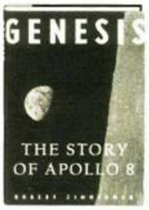
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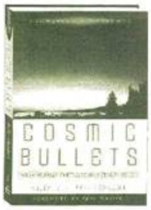
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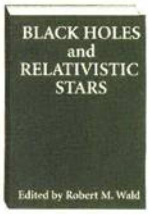
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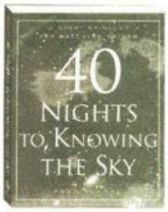
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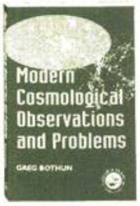
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Yes, generations that follow us will face significant challenges. But by the time we travel beyond the galaxy, explorers will have the technology to colonize target planets or to travel in perpetuity, as circumstances dictate. Their only enemy will be time. — *Rick Burges, Carrollton, Texas*

Eye on the Lost Prize

The arcane process of awarding of Nobel Prizes, as discussed in "Most Extreme Stars" in the January issue, led me to think about Jocelyn Bell. She was the actual discoverer of the Crab Pulsar, but the 1974 Nobel Prize in physics was awarded to her supervisor, Anthony Hewish, for "his decisive role in the discovery of pulsars."

Historians say that Hewish was tempted to discard Bell's data as artifact had she not proved conclusively that the origin of the radio source was not terrestrial.

Arno A. Penzias and Robert W. Wilson, both of Bell Laboratories, were the serendipitous discoverers of the cosmic background radiation, which garnered them the 1978 Nobel Prize in physics. Penzias and Wilson were trying to clear their antenna of unwanted noise. They beat out a Princeton University group studying theoretical aspects of why the background radiation must exist. Penzias and Wilson earned the award for doing something similar to what Bell had done. — *Loren Amacher, Hershey, Pennsylvania*

Correction

A story in the November issue of *Astronomy*, "Into the Maelstrom," described the Crab Nebula pulsar as emitting 1,800 thousand trillion amperes of energy per second; however, an ampere is a measure of the quantity of charge passing a point each second. Our apologies.

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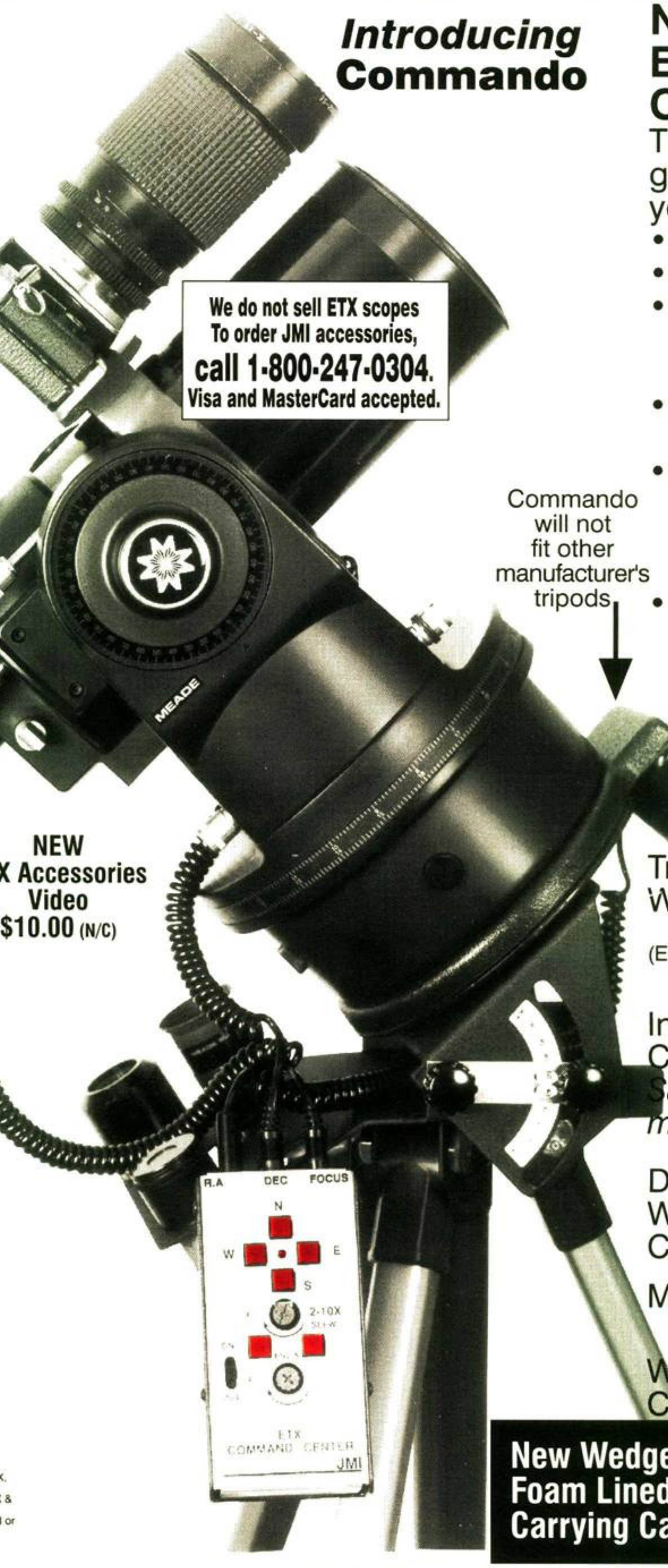

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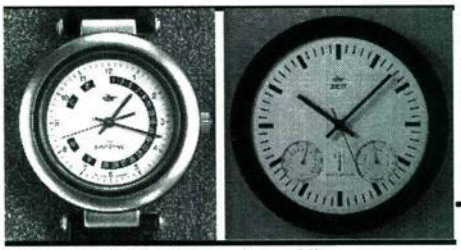

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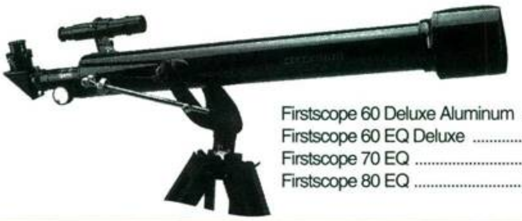

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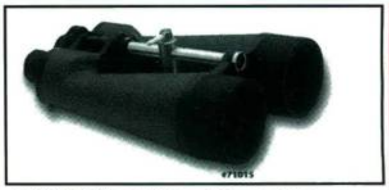

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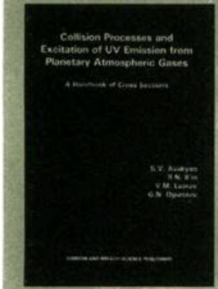
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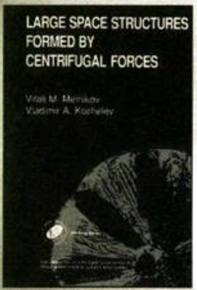
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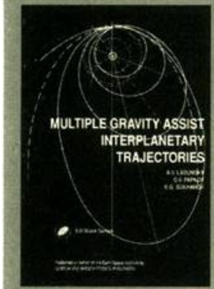
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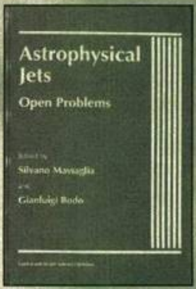
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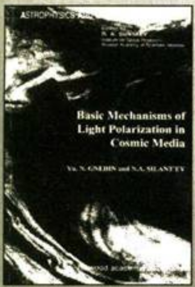
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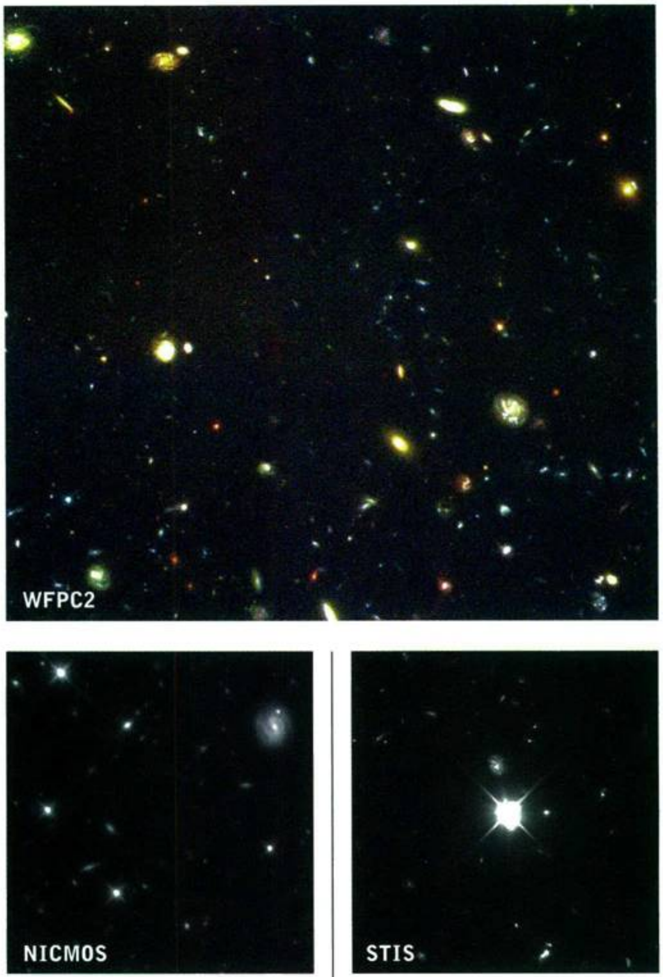
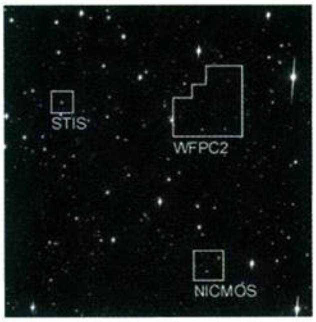
Hubble Goes South





The Hubble Deep Field South is actually three images in one. The WFPC2 image, taken mostly in visible light, is similar to the Deep Field image released in 1996. The NICMOS image was primarily taken in infrared light. The STIS image is mostly in visible and ultraviolet light; it contains a prominent quasar in the center. The ground-based image (above) shows the location of the three Deep Fields. The Hubble images are essentially tunnels through space and time, showing galaxies at varying distances. The faintest blips could be galaxies just a billion years after the Big Bang.

Robert Williams (STScI), the Hubble Deep Field-South Team, and NASA

▶ How long after the Big Bang did stars begin "turning on" in large numbers? How did galaxies assemble and evolve? Because most of this action occurred billions of years ago, astronomers must peer across a vast tunnel of space and time to answer these questions.

Sitting on its perch above the distorting effects of Earth's atmosphere, the Hubble Space Telescope is ideally suited for this task. In December 1995, Hubble stared for 10 full days at a tiny patch of sky near the Big Dipper. The resulting Hubble Deep Field, taken mostly in visible light by the telescope's Wide Field/Planetary Camera 2 (WFPC2), revealed more than 2,000 galaxies at various distances and, therefore, at different stages of evolution. Some of the galaxies were magnitude-30 blips that were seen as they existed just a billion years after the Big Bang.

But was the Hubble Deep Field representative of the universe at large? The universe should appear nearly the same in all directions, but astronomers wanted to make sure. So from September 28 to October 10, 1998, a team of 50 astronomers led by Robert Williams and Harry Ferguson of the Space Telescope Science Institute aimed the telescope at a sliver of sky in the southern constellation Tucana — in virtually the opposite direction as the Big Dipper.

Because space shuttle astronauts installed two new cameras since the time the northern Deep Field was taken, the southern Deep Field consists of three images taken simultaneously in neighboring fields. One image was taken by WFPC2 in virtually the same manner as the northern Deep Field. Hubble's Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) took an image in near-infrared light; this image is similar to a NICMOS image of the original Deep Field that was released last October (see "Deep Field, Part Deux," AstroNews, January 1999). The Space Telescope Imaging Spectrograph (STIS) took the third image; STIS also recorded the spectrum of a prominent quasar in the field. Each image will provide unique information about the formation and evolution of galaxies and the history of star formation in the universe.

The southern WFPC2 Deep Field image looks very much like its northern counterpart. "There's nothing stunningly different between the two fields," says Ferguson. "Of course, we didn't expect to see anything particularly different." At first glance, the only difference is that Deep Field South appears to contain fewer elliptical galaxies than Deep Field North.

"The southern Deep Field promises to be the most studied area of the sky over the next five years," adds Williams. In particular, astronomers will take spectra of the faintest galaxies with large ground-based telescopes to find out how far away they are. — Robert Naeye

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COSMOLOGY

Universe on Overdrive

▶ Albert Einstein called it his greatest blunder, and astronomers have long wished it would just go away. But it's beginning to look more and more as though the cosmological constant — a mysterious pressure that pervades the universe and causes space to expand faster as time goes on — is real.

Two independent teams of researchers have been observing distant type Ia supernovae — created when white dwarfs explode — to see how the expansion of the universe has changed with time. In early 1998, they announced preliminary results that showed the more distant supernovae belonged to galaxies receding from Earth slower than could be explained by a simple expanding universe controlled by gravity (see "Exploding Stars Tell All," November 1998). By the end of 1998, both teams had analyzed many more supernovae and the results look even stronger: The universe appears to be expanding faster now than it did in the distant past.

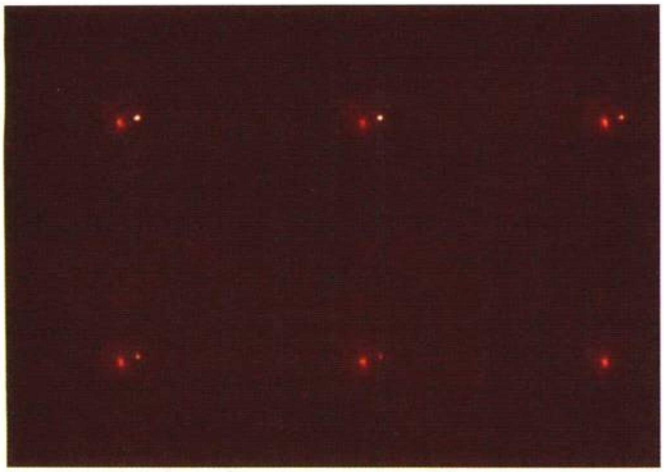
One team, led by Saul Perlmutter of the Lawrence Berkeley Laboratory, has now observed more than 80 type Ia supernovae and completely analyzed 42 of them. The other team, headed by Brian Schmidt of the Mount Stromlo and Siding Spring Observatories in Australia, has studied about 30 supernovae.

The teams come up with nearly identical results that support a cosmological constant. "If you lie the two distributions on top of each other," says Perlmutter, "one overlaps right on top of the other. It's really very beautiful." The results suggest that the universe will expand forever and at an ever increasing rate.

Both teams have studied supernovae so far away that they flared up when the universe was only half its current age. But despite their distance, these supernovae don't appear to be any different from those nearby. And dust, which would cause the more distant supernovae to appear fainter but also redder, doesn't seem to be the culprit either. "If the result is wrong, I think it's either due to something that no one has considered yet, or it's some sort of malicious conspiracy of a whole bunch of effects," says Alexei Filippenko of the University of California at Berkeley, a member of Schmidt's team.

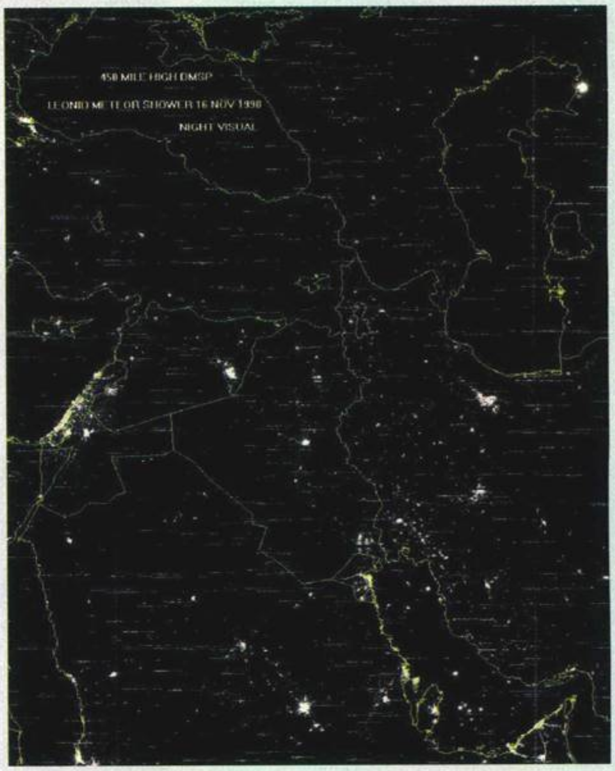
Both teams derive an age for the universe of between 14 billion and 15 billion years. For several years, observations implied that the universe was younger than its oldest stars. But the oldest stars now seem to be around 12 billion years. And because the cosmological constant increases the age of the universe, it offers a way to get around that troubling conundrum.

The editors of the prestigious journal *Science* recently cited the apparent discovery of a cosmological constant as the most important scientific advance of 1998. — RICHARD TALCOTT



The Hubble Space Telescope watched Supernova 1997cj fade away over a three-week period. Observations of such distant supernovae (1997cj lies some 5 billion light-years away) suggest that the universe is currently expanding faster than it did in the past. Peter Garnavich (CfA), the High-z Supernova Search Team, and NASA

METEORS



LEONIDS A'POPPIN'. On the evening of November 16, 1998, at the height of the Leonid meteor shower, a U.S. Air Force Defense Meteorological Satellite Program (DMSP) satellite recorded numerous meteor streaks, visible as horizontal lines. The satellite view shows a wide portion of the Middle East from an altitude of 450 miles (720 km), high above the meteors. Hank Brandli/DMSP, U.S. Air Force

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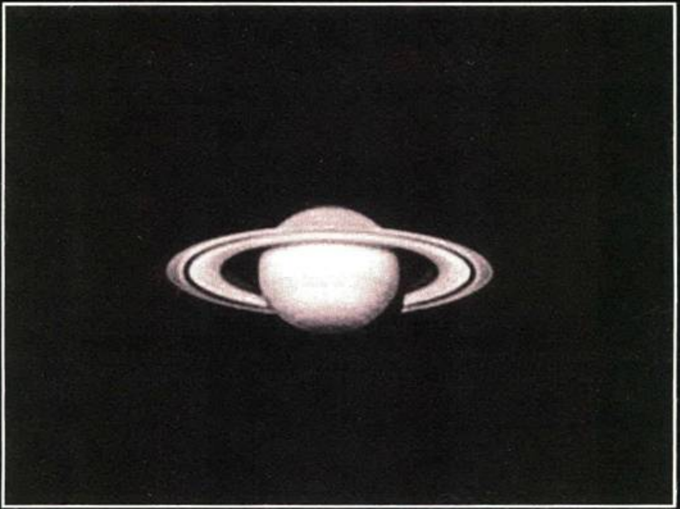

***Saturn.** This remarkable ST-5C image was taken from the rooftop of the observer's apartment building using a 10" f/10 SCT and 2X barlow. The image clearly shows the Cassini division, Encke gap, inner crepe ring, brightening in the ring structure and atmospheric detail on the planet. Courtesy Antonio Jose Cidadao, Member of A.P.A.A (Associaiacao Portuguesa de Astronomos Amadores).*

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EXTRASOLAR PLANETS

Eighteen and Counting

Astronomers have announced four new extrasolar planets, raising the grand total to 18 (including two planets orbiting a pulsar). In other words, astronomers have now found twice as many planets outside the solar system as there are within.

A team led by Geoff Marcy and Paul Butler has added three of the new extrasolar planets to the mix, raising the team's total to an even dozen. Two of the planets fall squarely into the "hot Jupiter" category. These planets have masses comparable to Jupiter, yet they orbit within 0.07 and 0.14 AU (1 AU is the Earth-sun distance) of the solar-type G stars HD 217107 and HD 195019, respectively. The third Marcy/Butler planet orbits the evolved G star HD 168443. The planet, which weighs in with at least five Jupiter masses, goes around the star in an elongated orbit at an average distance of 0.28 AU.

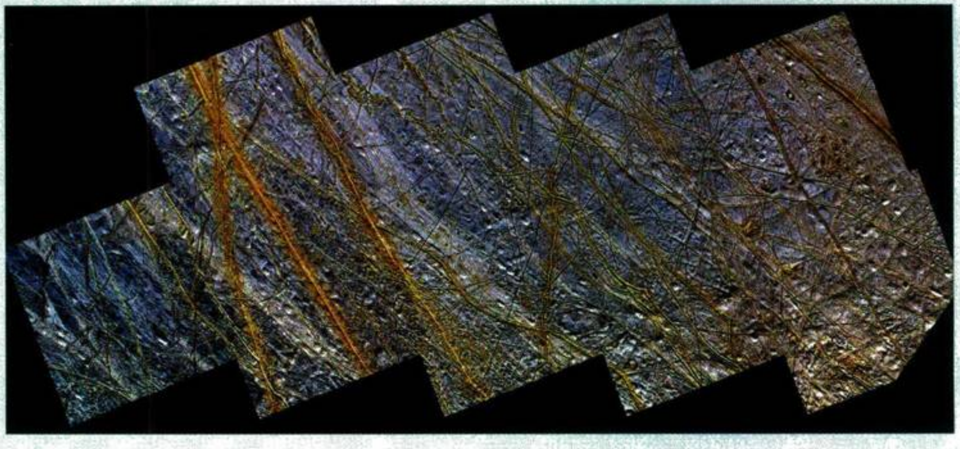
A Swiss/French team led by Michel Mayor and Didier Queloz has just bagged its third extrasolar planet. This behemoth has a mass of at least 4.9 Jupiters, and it orbits Gliese 86A, a cool K star. The planet orbits its sun at a distance of 0.11 AU, also putting it in the hot Jupiter class.

Eight of the 16 planets orbiting solar-type stars are hot Jupiters. "It appears that one to two percent of sun-like stars harbor these close-in, giant planets," says Debra Fischer, a member of the Marcy/Butler team.

Surprisingly, the other eight planets have orbits that are more elongated than those of Jupiter and Saturn. But all eight of these extrasolar planets are half as far from their parent stars as Jupiter is to the sun. "The remaining question is whether extrasolar planets at 5 AU (Jupiter's distance from the sun) also tend to reside in eccentric orbits," says Marcy. "If so, our solar system would represent the minority architecture of planetary system designs."

If you're having a hard time keeping up with these discoveries, join the club. "We have reached the era that Paul and I hoped would come to pass: We can't remember the names of all the extrasolar planets we've found," says Marcy. "We have too many planets, or too little brain-power; either way, we're happy." Adds Queloz, "We'll be announcing one new planet a month." To keep up with the frenetic pace of planet discovery, periodically check http://wwwusr.obspm.fr/departement/darc/planets/catalog.html.

GALILEO



EUROPA'S CRACKED SURFACE. The multilayered appearance of Europa comes across strongly in this high-resolution mosaic of the jovian moon. The brownish, linear ridges may be the remnants of water or partly molten water ice that erupted on the surface and froze almost instantly in the frigid conditions so far from the sun. The bluish surface represents a geologically older and smoother surface composed of almost pure water ice that lies under the ridge system. The mosaic, which covers an area of 500 by 220 miles (800 by 350 kilometers) and has been color-enhanced to bring out details, combines images taken during Galileo's 1st and 15th orbits. Though Galileo is operating normally, it went into a safe mode just six hours before its scheduled flyby of Europa on November 21–22 (its 10th Europa flyby), meaning it failed to collect any images or data. Engineers believe the problem was induced by the intense radiation surrounding Jupiter. NASA/JPL

SUPERNOVAE

The Closest Supernova Yet?

A giant star may have blown up in our celestial backyard in the 13th century. Two satellites spied the fiery aftermath of an apparent nearby supernova in the Southern Hemisphere sky, astronomers reported in the November 12, 1998, *Nature.* But the discovery is shrouded in mystery: Why are there no records of the explosion, which should have shone as brightly as a quarter moon?

The last supernova visible to the eye in our Milky Way Galaxy was observed by Johannes Kepler in 1604. Astronomers are puzzled why we haven't seen more this millennium, because the Milky Way should produce one or two of the titanic blasts each century. The new supernova, *if it withstands scrutiny,* would add one more to the list.

Astronomers spotted the object in two ways. First, the ROSAT satellite (which was shut down in December

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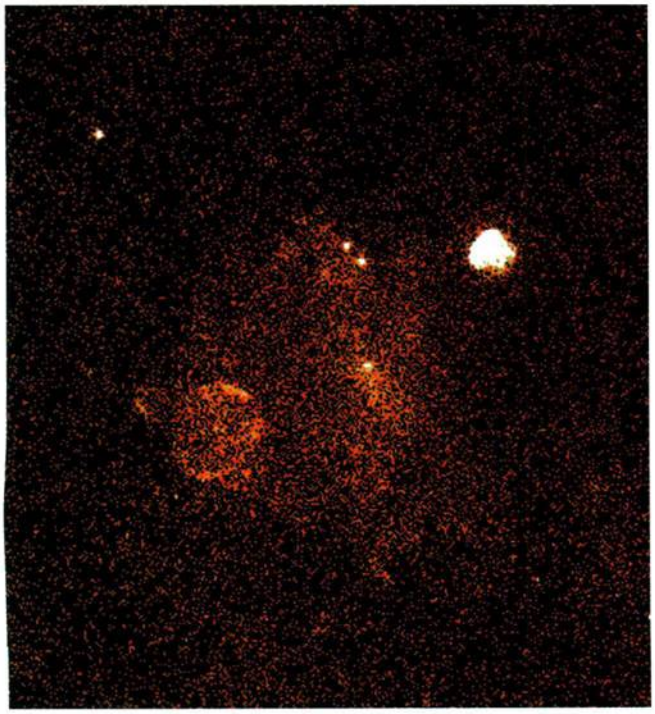
1998 after 8 years of successful observations) revealed a ring of x rays in front of the previously known large supernova remnant in the constellation Vela. The x rays point to a hot cloud of expanding debris that could only come from an even closer and younger supernova remnant, says Bernd Aschenbach of the Max-Planck-Institute for Extraterrestrial Physics in Germany.

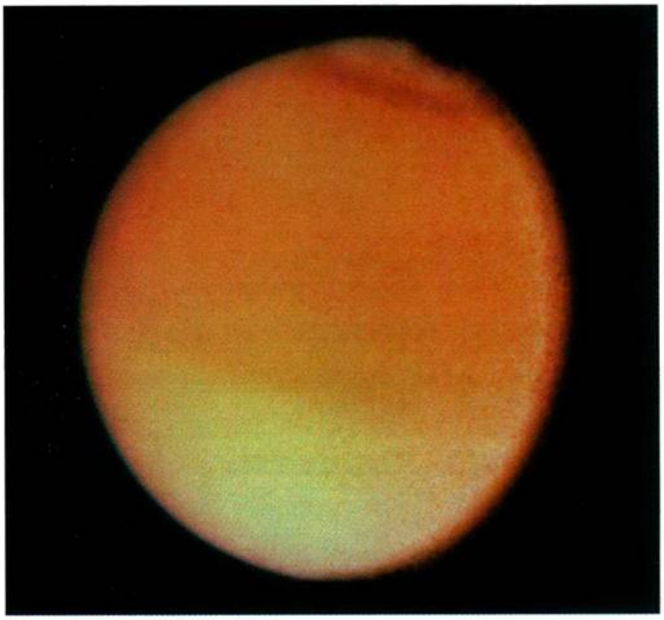
A second set of observations with an instrument on the Compton Gamma-Ray Observatory exposed high-energy gamma rays from the radioactive decay of titanium-44. That rare element is forged only in the infernos of supernovae. Because titanium-44 has a half-life of about 60 years, the current amount of the isotope suggests that light from the exploding star reached Earth about 700 years ago. And the size of the ball of x rays — four times the width of a full moon — shows the remnant is surprisingly close, just 600 light-years away. "This would have been far brighter than Venus if it was an ordinary supernova," says Aschenbach.

Astrophysicist Stan Woosley of the University of California, Santa Cruz, is excited by the find but says it needs confirmation. The lack of historic observations is troubling, he notes. "There could be oodles of dust between here and there, or else it may have been a strange supernova that was hard to see in visible light," says Woosley. Aschenbach adds that its southern location may have hidden it from sky-watching cultures of that era.

— Robert Irion



A glowing ring of x rays (lower left) in front of the Vela supernova remnant (the fainter background) may come from a newly discovered supernova blast from the 13th century. The explosion would be the closest yet found — just 600 light-years from Earth. Bernd Aschenbach (M.P.E.)



Voyager 1 revealed Titan to be a haze-enshrouded world devoid of clouds; new results paint a different picture. NASA/JPL

THE SOLAR SYSTEM

Clouds on Titan

▶ Saturn's large moon Titan has far and away the thickest atmosphere of any satellite in the solar system. But when Voyager 1 flew by Titan in 1980, it revealed a featureless, haze-enshrouded world devoid of clouds. Now that picture is changing.

In the October 8, 1998, *Nature*, planetary scientist Caitlin Griffith of Northern Arizona University and her colleagues announce the first direct indication of clouds on Titan. Although made of methane, and not water vapor like those on Earth, these clouds suggest a system similar to the water cycle on our home planet.

On Earth, water evaporates from the oceans, forms clouds, and then rains back down. Voyager 1 observations suggested that methane migrated the same way on Titan. Scientists thought that such a methane cycle was the only way to explain why methane in the atmosphere was not completely obliterated by solar ultraviolet radiation. Something — perhaps a methane ocean — must be replacing the methane, they reasoned.

But further ground-based observations failed to support this theory — until now. Griffith's team made its discovery by comparing near-infrared spectra taken on two nights in 1995 with spectra made in 1997. The 1995 spectra show that Titan's disk brightened by about 9 percent, but the 1997 views show no brightening. The team attributes the brightening to the presence of clouds in the lower atmosphere. If clouds are condensing, they could be coming from methane lakes.

Scientists haven't been able to peer through Titan's thick haze to spot any lakes. But the Cassini spacecraft, launched in 1997, will send the Huygens probe into Titan's atmosphere to take pictures and measure temperatures, pressures, winds, gas, and surface properties.

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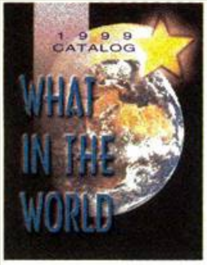

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Mention Ad A-7

"It is very difficult to investigate this question from Earth," says Griffith. "We will need to wait until Cassini reaches Titan in 2004 before we know whether there are oceans there." — TRACY STAEDTER

COSMIC RAYS

Space Streakers

▶ What could possibly accelerate a single subatomic particle to such a high speed, 99.99999999999999999999 percent that of light, that it would smash into Earth's atmosphere with the energy of a hard-hit tennis ball? If you don't have a clue, you're not alone.

These particles are ultra-high-energy cosmic rays, which are billions of times more energetic than the run-of-the-mill cosmic rays that continuously bombard Earth's atmosphere. Scientists have a hard time explaining how these rare cosmic rays could attain this stupendous energy because ordinary particles should be slowed, and therefore reduced in energy, as they plow through the cosmic microwave background.

Physicists Glennys Farrar of New York University and Peter Biermann of the Max-Planck-Institute for Radio Astronomy in Germany have identified a possible source. In the October 26, 1998, *Physical Review Letters*, they reported that each of the five highest-energy cosmic rays on record came from the same directions in the sky as five distant quasars that are particularly compact and powerful in radio waves. As Farrar says, "It is essentially a perfect fit."

Powerful magnetic fields in the vicinity of the quasars' supermassive black holes could be accelerating protons to nearly light speed. The protons smash into surrounding material, producing secondary particles that travel billions of light-years to Earth as ultra-high-energy cosmic rays. "There's a lot of material around these compact, radio-loud quasars to produce targets for the protons, so this is the kind of place that could make exotic cosmic rays," says Farrar.

But Farrar isn't sure if her result is anything more than a statistical fluke, even if the odds of that are less than one percent. The secondary particles would have to be neutral in order to avoid being slowed by the cosmic microwave background or deflected by interstellar magnetic fields. The only neutral particles that could do the job are ones that have either not been proven to exist or that would involve improbable physics. "This is an interesting paper, but they're asking for a lot of miracles," says University of Chicago physicist and Nobel laureate James Cronin.

A new generation of detectors soon to come on line will be able to pinpoint cosmic ray origins to much higher precision. "If they get one with high accuracy, and it has one of these rare quasars behind it, then I'll believe it," says Farrar. A

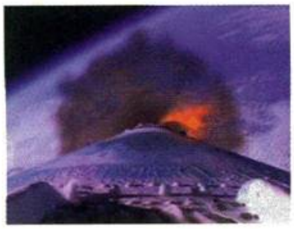
WEBSITE

Check *Astronomy*'s website for news as it happens — http://www.astronomy.com.

Pulsars Now Number a Thousand

An international team of astronomers from Australia, England, Italy, and the United States has just discovered the 1,000th known pulsar. The team found the rapidly rotating neutron star — the crushed remains of an exploded star — in November 1998 as part of a massive search for radio pulsars in the plane of the Milky Way Galaxy. Using the 64-meter Parkes Radio Telescope in Australia along with a new multibeam receiver, the researchers have logged about 200 new pulsars in the past year — a record pace — and expect to find some 600 more by the end of the survey.

Good News for NASA



Mars Climate Orbiter is on its way to Mars. NASA

On December 11, 1998, Mars Climate Orbiter successfully blasted off from Kennedy Space Center for a 9-month journey to the Red Planet. Everything is also going well with NASA's Saturn-bound Cassini mission and the Deep Space 1 mission. On December 3, Cassini executed a 90-minute rocket burn to set it on course for a second Venus gravity assist in June. After a few early glitches, Deep Space 1's novel ion propulsion system operated from November 23 to December 8 — twice as long as originally planned.

Where Next, NASA?

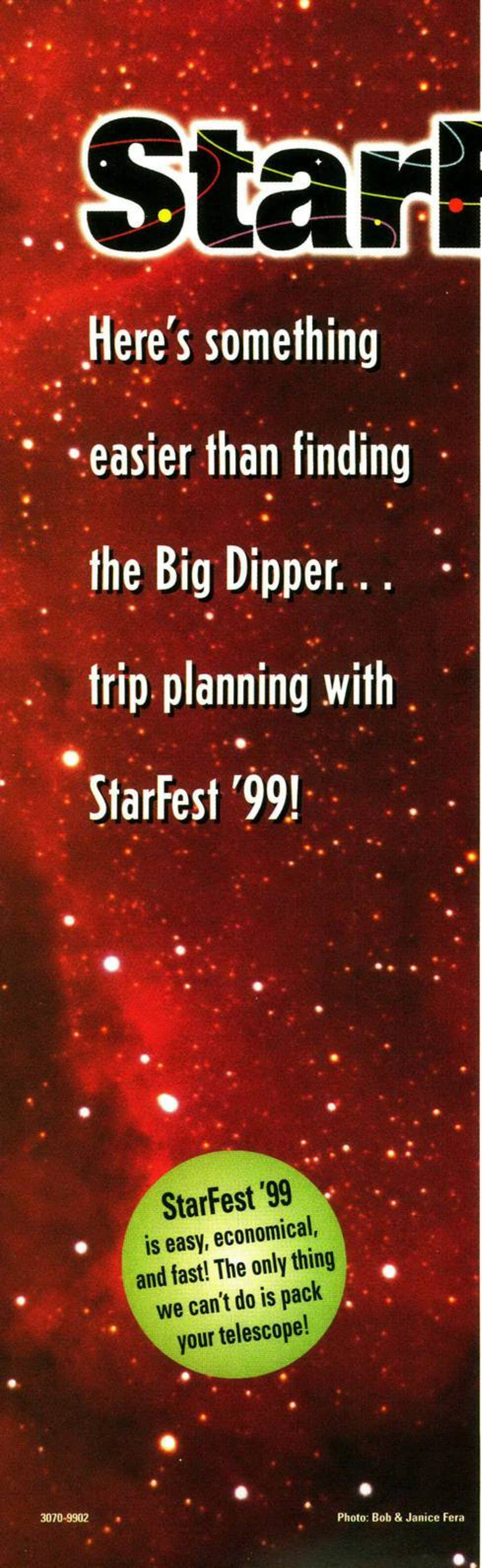
NASA has selected five out of 26 low-cost Discovery-class mission proposals for detailed feasibility studies. The missions are designed to gather samples of the martian moons, Phobos and Deimos; fire a 1,100-pound (500-kg) copper projectile into comet P/Tempel 1; study Jupiter's interior; globally image and study Mercury; and measure the composition and circulation of Venus's middle atmosphere. One or two of these missions will be selected for full development in June. Among the 21 missions not approved was a proposal to send a robotic airplane to Mars in December 2003.

Three New Members Join the Club

You might think that by now astronomers would have a complete census of the Local Group, the galaxy cluster to which the Milky Way belongs. Think again. Many dwarf galaxies are so intrinsically faint that even nearby ones can barely be seen. By analyzing data from the new Palomar Sky Survey, two teams of astronomers have recently found three new members of the Local Group. The dwarfs are about 2.5 million light-years away and contain a few million stars each. Their discovery brings to 35 the total known members of the Local Group.

Astronomy Magazine

StarFest '99



StarFest '99 leaves the hassles of travel planning—endless phone calls to airlines, searching the Web for hotels, haggling prices for car rentals—to the experts. Now, you're only one step away from enjoying the night skies at an *Astronomy* Magazine cosponsored event.

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- **Astronomical Society of the Pacific • July 1–7**
  (Includes Universe '99 - July 2–4) Toronto, Ontario, Canada
  Register with Lori Keechler at (415) 337-1100 or e-mail lkeechler@aspsky.org
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- **Oregon Star Party • August 20–23**
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- **Enchanted Skies Star Party • October 8–11**
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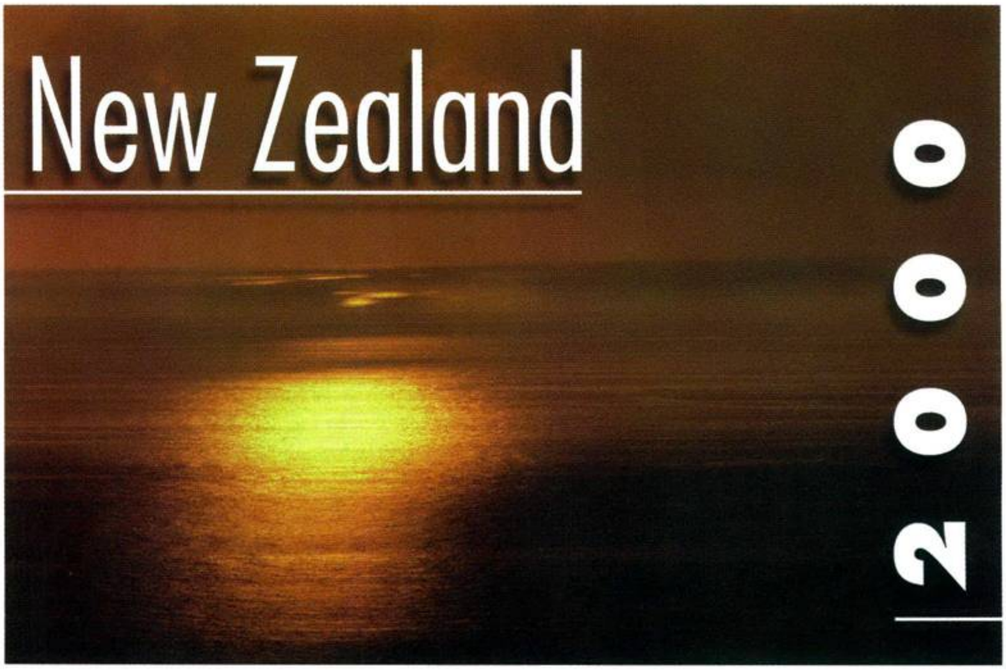
Astronomy Magazine presents

The Millennium Tour



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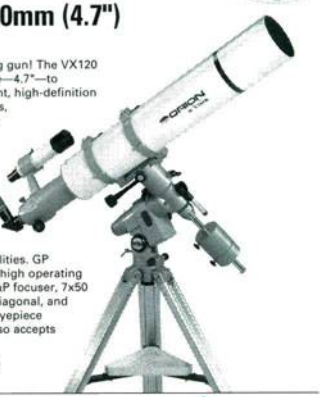

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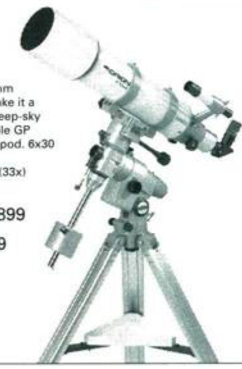

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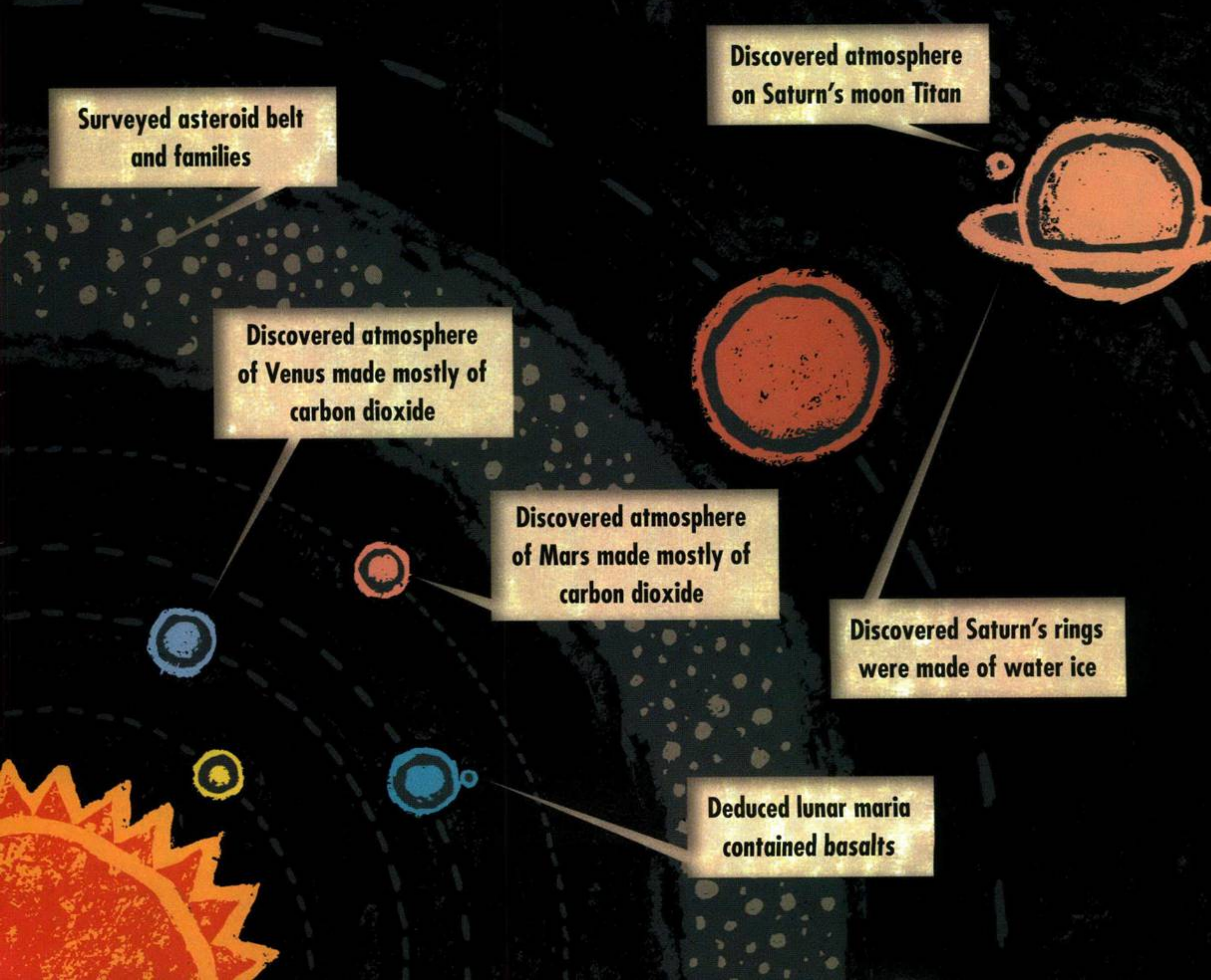
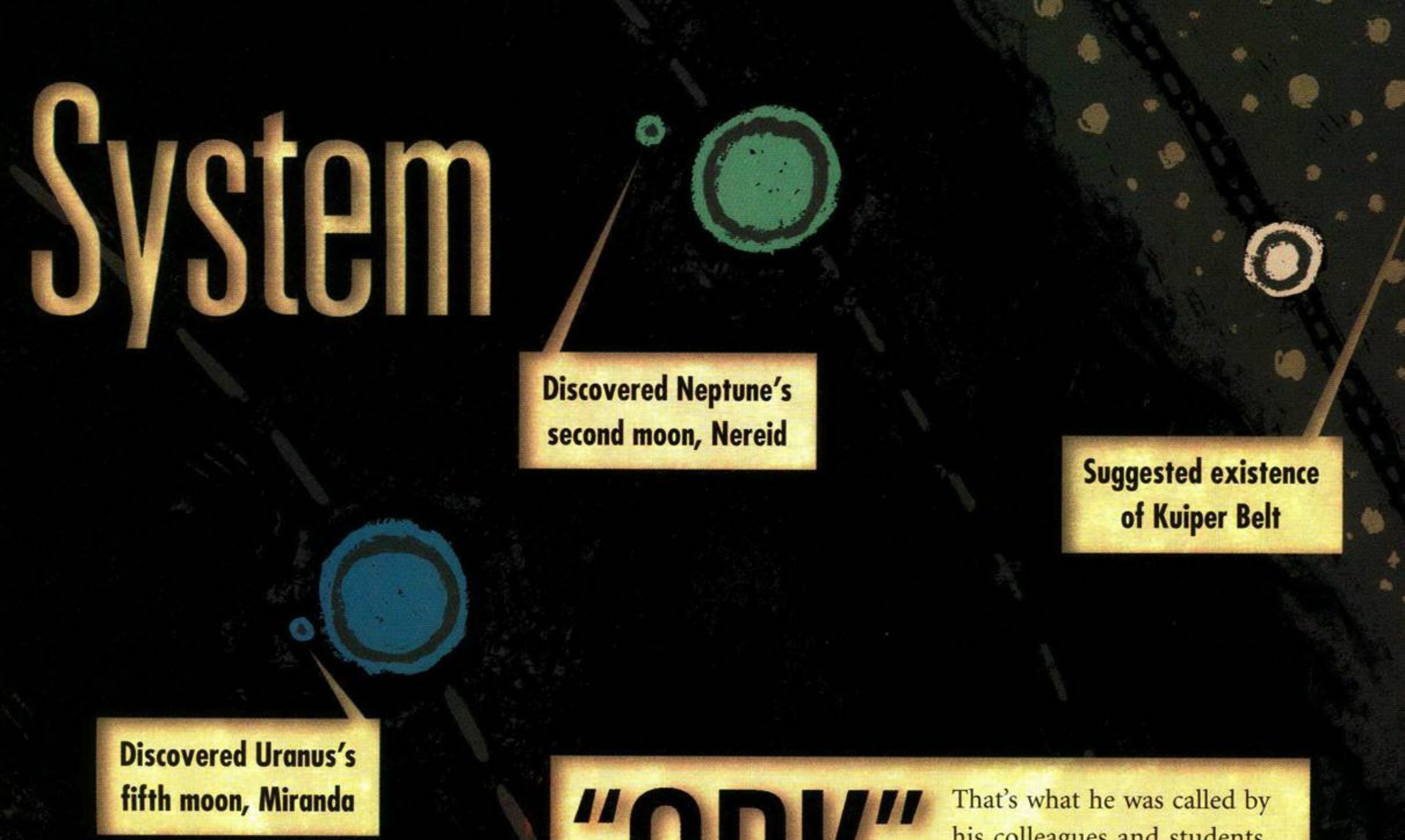
Forging a New Solar

Few people have entire regions of the solar system named after them, but then few people contributed as much to planetary astronomy as Gerard Kuiper. By S. Alan Stern

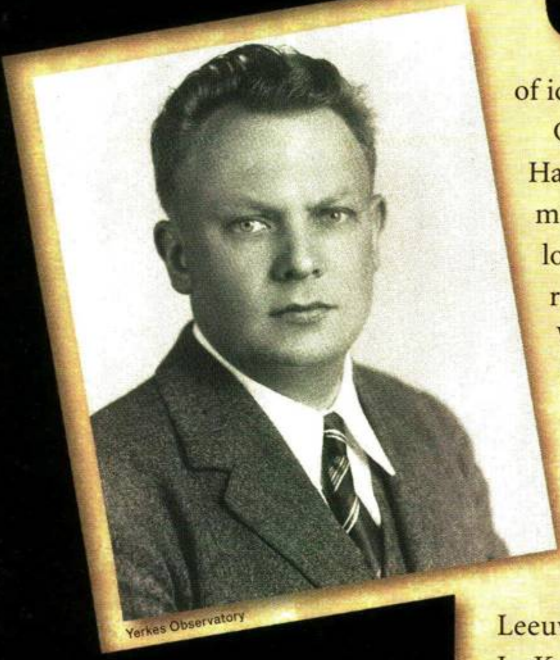

Discovered atmosphere on Saturn's moon Titan
Surveyed asteroid belt and families
Discovered atmosphere of Venus made mostly of carbon dioxide
Discovered atmosphere of Mars made mostly of carbon dioxide
Discovered Saturn's rings were made of water ice
Deduced lunar maria contained basalts

System


Discovered Neptune's second moon, Nereid
Suggested existence of Kuiper Belt
Discovered Uranus's fifth moon, Miranda

Astronomy: Terri Field

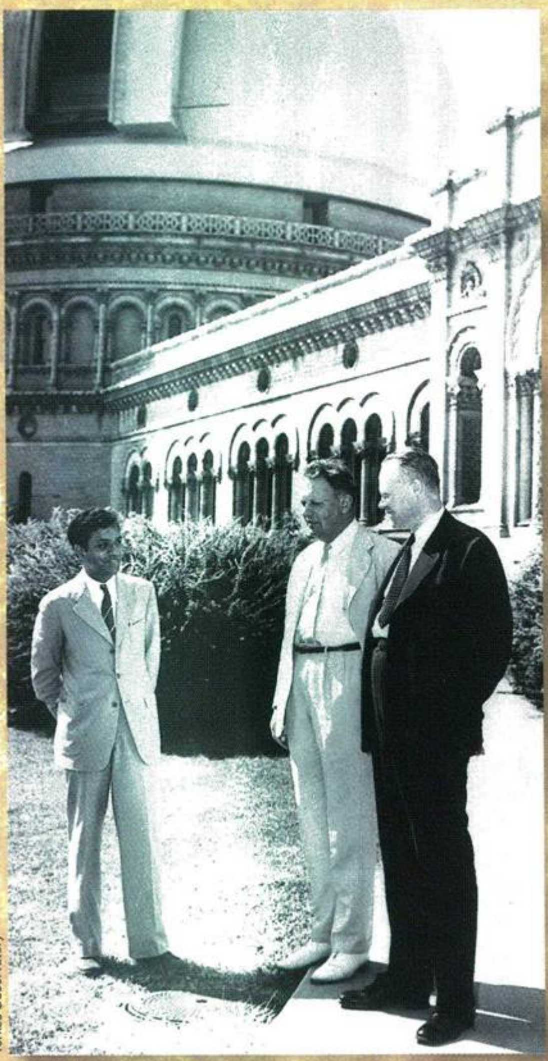
"GPK" That's what he was called by his colleagues and students. Gerard Peter Kuiper was the Dutch-American father of modern planetary astronomy, turning a moribund science into a thriving marketplace of ideas little more than a half-century ago.



Yerkes Observatory

Gerrit Peter Kuiper was one of four children, born in Harencarspel, the Netherlands, on December 7, 1905. Like many astronomers, Gerrit (later "Gerard") Kuiper had his love for the science sparked early. In Kuiper's case, it was a reading of Descartes that fired his interest in astronomy. When he graduated from his gymnasium (high school) in Haarlem, the Netherlands, Kuiper chose to study physics and chemistry at the University of Leiden.

Leiden is a small town, just south of Amsterdam and barely 20 miles from the North Sea. Its university, however, looms large — having trained and harbored exemplary scientists for centuries, including Antoni van Leeuwenhoek (the naturalist and pioneer in microscopy). In Kuiper's day, the physics and astronomy faculty at Leiden included such great scientists as Jan Woltjer, Willem de Sitter, Ejnar Hertzsprung, and Paul Ehrenfest. Kuiper completed his bachelor of science degree at Leiden in three years, and in 1927,



Yerkes Observatory

Gerard Kuiper (middle) stands outside Yerkes Observatory with Subrahmanyan Chandrasekhar (left) and Otto Struve.

began his Ph.D. studies there. Kuiper's professors described him as a "bright, brash researcher zealously dedicated to observational work."

Kuiper's incoming graduate "class," such as it was, consisted of just two students, GPK and Bart J. Bok. Both young men were destined to become 20th-century legends. Bok later recalled on meeting Kuiper, that "After introduction formalities were over, Gerard asked me what was my specialty field of interest in astronomy. I promptly replied that I was interested in the Milky Way and Cepheid variable stars. He responded, 'That is not an uninteresting field. But I expect to study a more fundamental area, the problem of three bodies and related questions about the nature and origin of the solar system.'"

Bok stayed with his interests in galactic astronomy, becoming one of the leading authorities in the study of the Milky Way until his death in 1983.

Kuiper, by contrast, might have meant to start out in solar system astronomy, but so little was known reliably that he found himself studying binary stars as, he hoped, an analogy to planetary formation. Kuiper's doctoral thesis, mentored by Hertzsprung and the great polymath astronomer Jan Oort (who was later to "discover" the Oort Cloud), focused on the statistics of binary stars. When he finished in 1933, Kuiper immediately moved to the United States, where he took a postdoctoral research fellowship at Lick Observatory in California. At Lick, Kuiper continued his studies of binary stars, eventually finding the then-surprising result that 50 percent of the nearest stars belonged to binary systems.

Throughout the 1930s and the beginning of the 1940s, first at Lick, then at Harvard, and later at Yerkes Observatory, Kuiper continued and deepened his research specialty in stellar astronomy. During this first period of his career, he made a seminal study of the relationship between mass and luminosity for main sequence stars, studied the evolution of stars, examined color-magnitude diagrams for open star clusters, observed white dwarfs and refined their masses, and (with Otto Struve and Bengt Strömgren) performed the classical study of the eclipsing binary, Epsilon Aurigae. Kuiper's investigation of the mass-luminosity relation for main-sequence stars remained a standard in the field for 50 years. His landmark 1941 paper on the star Beta Lyrae introduced the term "contact binary." And at one time Kuiper had amassed two-thirds of all the white dwarf discoveries in the world.

While at Harvard, Kuiper met and, in June 1936, married Sarah Parker Fuller. The couple later produced two children, Paul and Lucy. Kuiper took American citizenship in 1939–1940 and then joined the war effort as a civilian in the War Department's Office of Scientific Research and Development. Later in World War II, he worked in the Operational Analysis Section of the 8th U. S. Army Air Force in England.

To Titan and Beyond

During the War, Kuiper's thoughts began to turn to what would become his most notable work: the exploration of the solar system. In contrast to today, in the 1930s and 1940s planetary studies were seldom undertaken and only a few researchers plied the solar system for results. But Kuiper's budding interests would soon boom into an energetic, full-blown assault on the solar system that would come to completely dominate solar system research in North America.

Kuiper's first foray into this "new" area took place during a winter leave from military-related duties in 1943. He undertook an observing campaign at McDonald Observatory, which his home institution, Yerkes, then operated, to search for evidence of atmospheres around the satellites of planets. Using the 82-inch reflector, at that time the third largest telescope in the world, GPK took high-resolution spectra of almost a dozen moons in the outer solar system. He hit the jackpot with

Saturn's Titan, where he found clear and unambiguous evidence for gaseous methane.

It was a landmark discovery. Never before had moons, those small worlds revolving about larger ones, been known to possess atmospheres as planets did. In fact, Henry Norris Russell had published an influential review of planetary atmospheres in 1935 stating the paradigm that giant planets had hydrogen atmospheres, smaller planets had atmospheres with oxygen-bearing molecules, and the smallest planets and satellites had no atmospheres at all. Yet Kuiper had found proof that Titan was a satellite with an atmosphere — a paradigm had been shattered.

Although Kuiper's techniques were too primitive to detect the tenuous atmospheres we now know to exist around the jovian moons Io and Europa and Neptune's Triton, his studies of satellites continued for much of his career. Among his most notable results were the discovery in 1948 of Uranus's fifth satellite, Miranda, and in 1949 of Neptune's second moon, Nereid.

More notable still was Kuiper's application of new infrared technology to the study of planets and their satellites and rings. In 1944 and 1945, he was a scientist sent by the U. S. Department of Defense (officially the Department of War at that time) to "interview" Axis-country scientists about their advanced technologies, particularly in nuclear science and rocketry. While doing this, Kuiper discovered that German scientists had perfected an infrared detector with a sensitivity that was then unparalleled.

Kuiper realized that these devices, made of lead sulfide, could open up a rich new arena for astronomy. When he returned to the United States after the end of World War II, Kuiper used this knowledge, which he worked to have declassified, to show Penn State researcher R. J. Cashman the European recipe for perfecting lead-sulfide detectors, which Cashman had previously tried but failed to make.

With Kuiper's information, Cashman succeeded, and the "Cashman cells" thus produced gave Kuiper the capability to make dramatic new discoveries in planetary science. Within a few short years after the War, Kuiper discovered that Saturn's rings were made of water ice, that carbon dioxide dominated the atmospheres of both Mars and Venus, and that the martian polar caps underwent seasonal growth and recession.

As the 1940s turned into the 1950s, Kuiper applied his ambition, skill, and copious observing resources at Yerkes. He made the most complete survey of the asteroid belt ever undertaken up to that time, searched for moons around Pluto, attempted to measure Pluto's true size (an effort at which he failed), and studied the dynamics of the giant planets' atmospheres. At the same time, while undertaking two stints as Director of Yerkes Observatory, Kuiper organized major interdisciplinary conferences that brought physicists, chemists, and meteorologists together with astronomers to explore the nature of planetary atmospheres. In doing so, Kuiper sowed the seeds of the modern discipline.

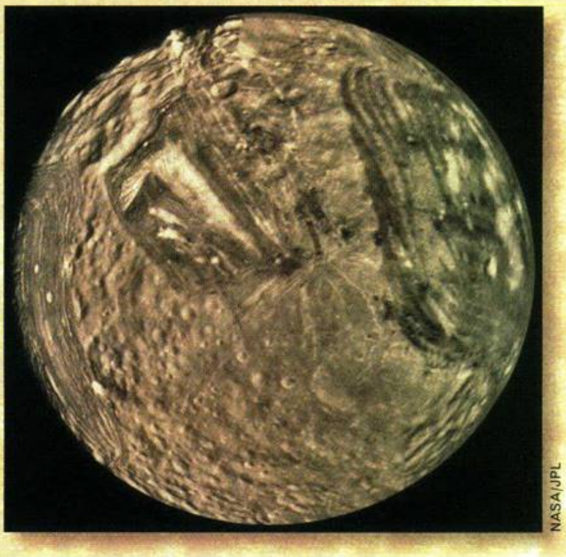
During the same period, Kuiper began his four volume encyclopedia of the solar system (a project with no parallel), and later, his nine volume set, *Stars and Stellar Systems.*

Around this time, Kuiper also began to apply his thoughts to the study of the origin of the solar system. He proposed a new theory of planetary origins in which each planet formed from its own gas cloud and suggested that the high-speed solar wind was responsible for dispersing most of the hydrogen of the primordial solar nebula. He also proposed, based in part on his earlier studies of binary and multiple star systems, that planetary systems, which astronomers previously had

Kuiper served as principal scientist for Ranger, which sent back the first close-up pictures of the moon's surface.

NASA

Discovered by Kuiper in 1948, Uranus's moon Miranda showed its complex geology to the Voyager spacecraft.


NASA/JPL

thought to be exceedingly rare — perhaps as rare as only one in a trillion stars — might be found around up to 1 percent of all stars.

And there was more. Kuiper published key studies on the nature of the Hirayama asteroid families and the irregular satellites of Jupiter. And he presciently proposed that just beyond the planets there likely lay a vast debris belt of comets and other small bodies left over from the formation of the solar system.

But the more GPK studied the outer solar system, the more he came to realize that a body far closer might hold significant clues to the study of how the solar system formed. This was how Kuiper came to turn his attention to, of all things, Earth's moon.

Hot on the Moon

Kuiper was correct in his intuition that the moon held many important secrets about the earliest days of the solar system. And as the 1950s turned into the 1960s, the world's burgeoning interest in space exploration was about to explode into an era of lunar exploration no one could have foretold. Soon, the Apollo program would be born, and with it came dozens of robotic and nine human missions to the moon.

Kuiper himself began by studying the craters of the moon, carefully building up a photographic database called the *Photographic Lunar Atlas*. It became a rich source of both scientific results and mapping information for the lunar exploration missions that would follow.

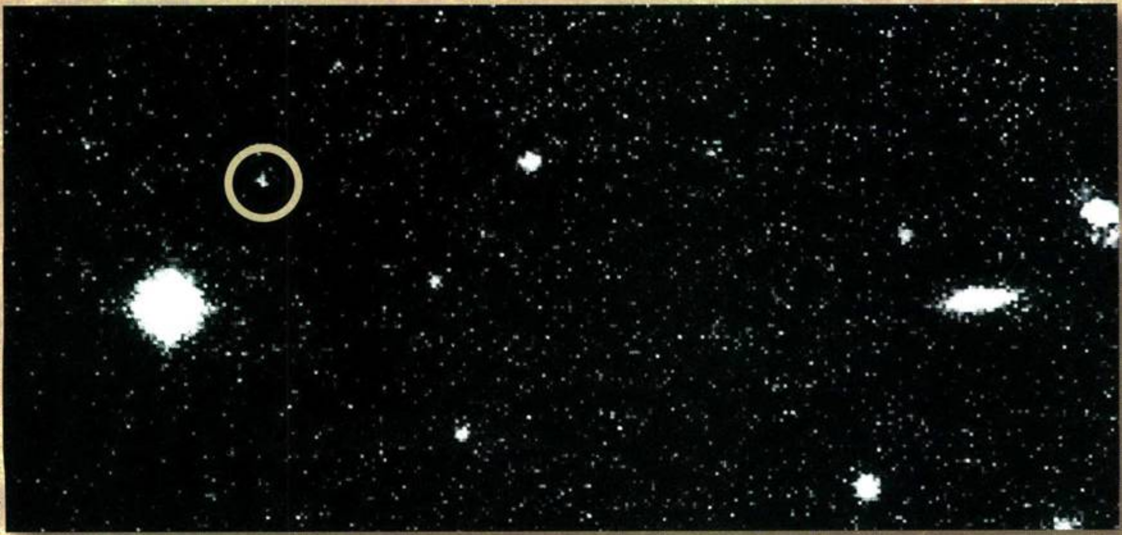
As Kuiper became increasingly interested in solar system studies, he also became further isolated from mainstream astrophysics. Simply put, planetary studies were viewed — incorrectly, as it turned out — as a backwater of astronomy. This intellectual isolation, along with his relatively autocratic leadership style and interpersonal struggles with some of his senior colleagues at Yerkes, caused him to lose the directorship of Yerkes Observatory at the start of 1960.

Being resourceful, Kuiper turned this setback to his advantage by arranging to start a major center for solar system astronomy at the University of Arizona in Tucson. Calling his new center the Lunar and Planetary Laboratory (LPL), Kuiper moved himself and nine members of his staff and student cadre to Tucson in mid-1960. By 1962, planetary exploration was kicking into high gear. With NASA's Lunar Ranger, Surveyor, and Apollo programs, as well as the Mariner series of planetary flybys, LPL (sometimes referred to as the "Looney Lab") employed 30 staff scientists, technicians, students, and aides. By 1966 the Laboratory's roster topped 100 individuals, with facilities ranging from their own multistory office building to a suite of telescopes in the Catalina Mountains north of Tucson and a set of infrared astronomy instruments plying the stratosphere on both NASA and military aircraft.

And all the while, Kuiper continued his research. He verified the pressure at the base of Mars's atmosphere; he deduced that the lunar maria were basaltic; he discovered a new class of absorption bands in the spectra of cool stars; and he served as the principal scientist for NASA on the Ranger program, the first series of lunar missions in preparation for Apollo. The Ranger flights produced the first close-up pictures of the lunar surface and showed that the moon's surface had sufficient strength to support manned landers.

Even in the 1960s, three decades into his career, Kuiper loved to be at the telescope. The eminent planetary scientist Dale Cruikshank, then one of his students, described Kuiper's observing style as, "Indefatigable. . . . [A] full nighttime schedule of infrared spectroscopy of stars and planets was supplemented by a daytime program of very bright stars, Venus, or Mars. . . . During these periods, at times amounting to 14 consecutive clear days and nights at McDonald, Kuiper would exist

The first member of the Kuiper Belt ever seen was this inconspicuous point of light (circle) designated 1992 QB_1.



European Southern Observatory

NASA/JPL

Kuiper discovered the thick, hazy atmosphere of Saturn's moon Titan, seen here up close by Voyager's camera.

on three hours of sleep each day, while another assistant and I would each work 10-hour shifts."

Although Kuiper's explorations and results kept up a furious pace throughout the 1960s, his most well-known work concerned the origin of the moon. Kuiper initially became interested in this problem at the end of the 1940s and had pursued it throughout the 1950s. He had come to believe that the moon formed in a hot, molten state and that the surface geology seen in his mapping efforts was evidence. Kuiper's arguments for a hot origin of the moon were also supported by geochemical evidence.

This work was not without controversy, however, and in fact Kuiper was engaged in a severe debate with the Nobel Prize-winning chemist Harold Urey over whether the moon had formed cold or hot. The Kuiper-Urey debate raged — always vociferously and sometimes even bitterly — for more than 15 years. But when lunar samples were returned by Apollo astronauts, the debate was finally settled: The Moon had indeed formed hot — so hot, in fact, that it sported a magma ocean in its youth. Kuiper had been right, not entirely for the correct reasons, as the samples revealed, but he had been right.

Lasting Legacies

As the Apollo program closed out in the early 1970s, Kuiper became involved in both the Mariner 10 flyby of Mercury and the Pioneer 10 and 11 missions to reconnoiter the Jupiter system. He also retired, at age 67, from the directorship of his creation, the Lunar and Planetary Laboratory.

In late 1973, with Pioneer 10 making the first-ever crossing of the asteroid belt on its way to Jupiter and Mariner 10 within weeks of its first approach to Mercury, Kuiper left Tucson for a vacation to Mexico. Without warning, on Christmas Eve 1973, he collapsed and died while in Mexico City.

Although he was not able to participate in the historic planetary explorations of Mercury and Jupiter that followed in the next several weeks, nor to publish his long-anticipated new cosmogony of the solar system, his life's work lived on.

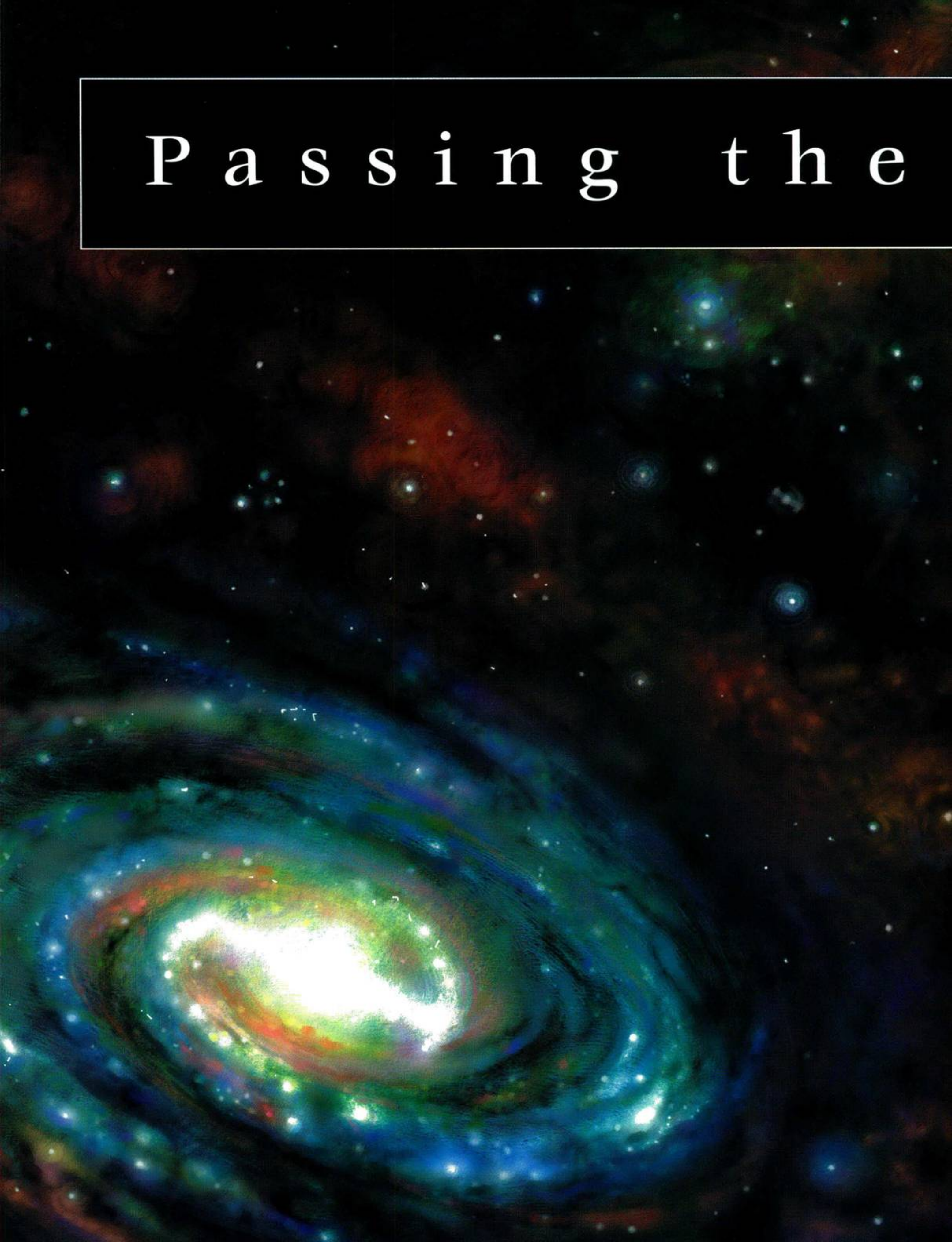
The Apollo missions proved he was largely correct about the moon's early, hot phase and the nature of its craters. So too, his work on asteroid families, the origin of the jovian satellites, and the nature of Mars's polar caps was confirmed. Most dramatically, however, his once-fantastical prediction of a debris belt of comets just beyond the planets was borne out in the late 1980s and early 1990s. And in his honor, that structure, the Edgeworth-Kuiper Belt, now bears his name.

Kuiper's work also lives through the contributions of the many fine Ph.D. students whom he trained. These include Alan Binder, Dale Cruikshank, Tom Gehrels, Dan Harris, Bill Hartmann, Toby Owen, and Carl Sagan.

After Kuiper died, NASA named its airborne infrared observatory in his honor, the Kuiper Airborne Observatory. And the University of Arizona named the LPL building the Kuiper Space Sciences Building. His scientific colleagues named prominent craters on the moon, Mars, and Mercury for him — an honor no other human being has earned. Yet perhaps the best commemoration of his life is the simple statement that, Gerard Kuiper, more than anyone else, was responsible for restoring solar system astronomy to prominence in an era dominated by stellar and galactic research.

S. Alan Stern is a planetary scientist in the Southwest Research Institute's research group in Boulder, Colorado. He and Jacqueline Mitton recently co-authored Pluto and Charon: Ice Worlds on the Ragged Edge of the Solar System *(John Wiley & Sons, 1997).*

Passing the



Bar Exam

Astronomers have discovered that the Milky Way Galaxy is a barred spiral.

by Michael Szpir

WHAT WOULD THE MILKY WAY GALAXY LOOK LIKE TO AN observer in another galaxy? For many years textbooks answered this question with a photograph of a normal spiral galaxy, one with a nice round bulge in the center. Read some recent editions, however, and you may notice a qualifying statement to the effect that . . . well, it just might be a barred spiral galaxy.

Despite the hesitation in the textbooks, it's a question that has indeed been answered: The Milky Way *is* a barred spiral galaxy — one with an elongated stellar bulge in the center. In fact, the weight of evidence is now so overwhelming that the bar's existence is uncontested by specialists who study the galactic bulge. According to David Spergel of Princeton University, "The question is no longer whether the bar exists, but what its properties are, how it formed, and what its relevance is to understanding the evolution of our galaxy."

In hindsight, perhaps nobody should have been surprised. Most spiral galaxies show at least a hint of a central bar, and about half of those spirals whose bar is particularly prominent are deemed worthy of membership in the "barred spiral" club.

Still, it's a dramatic change in perspective that's only come about in the past few years. If you feel a certain sense of discomfort with the notion that astronomers are just getting around to answering such basic questions about the structure of our galaxy, then you're in good company. As Leo Blitz of the University of California at Berkeley puts it, "What's most astonishing to me about the galaxy's bar is that people have been looking at the Milky Way for thousands of years and only now have we found this major structure."

A Bar's Signature

How did generations of skygazers and astronomers miss it? In a word: dust. There's so much dust in the galactic plane that our view of the bar is completely obscured in visible light. To peer into the center of our galaxy astronomers must rely on telescopes sensitive to longer-wavelengths — infrared and radio — which simply pass through the dust.

Radio observations of the galactic bulge had led a few astronomers in earlier generations to propose that the Milky Way might be a barred spiral. Hugh Johnson of Ohio State University in the 1950s and Gérard de Vaucouleurs of the University of Texas in the 1960s made such proposals based on the non-circular orbits of neutral hydrogen (HI) gas in the galactic bulge. At the time, however, most astronomers did not find their arguments particularly compelling.

Astronomers have come to realize that we live in a barred spiral galaxy.

Astronomy: Elisabeth Rowan

It was not until 1975 that the thesis work of University of Texas graduate student Bill Peters provided more solid ground for the bar's existence. Peters analyzed the hydrogen emission from the galaxy's inner region and showed that the gas appeared to be moving along elliptical orbits, most naturally explained as a response to a bar. Astronomers had previously interpreted these motions as a combination of expansion and rotation in the galactic center. Peters's explanation was considered to be more elegant because the supposed expansion would have required enormous explosive energies.

The astronomical community might have accepted the idea that the Milky Way was a barred spiral then and there if it had not been for the dissent of the great Dutch astronomer Jan Oort (of Oort Cloud fame), who paid scant attention to Peters's work in an influential paper published in 1977. At the time, most astronomers sided with Oort, who was, after all, the one who conceived the idea of using radio waves to study the Milky Way's structure — the technique that ultimately revealed our galaxy's spiral arms. "It is my belief that Oort's strong opposition really hampered progress in identifying the bar," says Blitz.

As it turned out, it took astronomers decades to convince themselves that Johnson, de Vaucouleurs, and Peters were indeed correct. Aside from Oort's powerful influence, another reason it took so long was that the earlier proposals were based on indirect evidence: The radio observations of hydrogen gas did not reveal the bar itself, only its effects on the surrounding medium.

It was not until 1991 that Blitz and Spergel found the first direct evidence for the galactic bar. Using data gathered by other scientists nearly 10 years earlier, Blitz and Spergel showed that the infrared emission on the eastern half of the galactic bulge is brighter than that on the western half. Their interpretation: The east side appears brighter because the average distance from the sun of stars on the east side is closer to us than the average distance of stars on the west. In

Lick Observatory

If we could look at the Milky Way Galaxy nearly face-on, it would look similar to this barred spiral galaxy, M109.

other words, the east side corresponds to one end of the galactic bar that is pointing almost directly toward us. Blitz and Spergel also showed that the infrared light passes three other tests of a bar-like distribution of stars, and is inconsistent with a symmetric bulge-like distribution.

Soon after the Blitz and Spergel discovery, other groups of astronomers began to find additional evidence of a galactic bar. Some of the most compelling work is based on the three-dimensional distribution of certain types of stars in the bulge, such as Mira-type variable stars. These stars have a well-established relationship between their intrinsic brightness and the timing of the periodic variations in their brightness. By comparing their apparent brightness (which can be observed) to their intrinsic brightness (which can be deduced), astronomers can estimate their distances. Several studies indicate that Mira-types on the east side of the galactic center tend to be closer to us than those on the west side. This is precisely the distribution expected from a bar oriented in the manner suggested by the Blitz and Spergel study. Astronomers have since discovered that other types of stars follow a similar distribution.

Further support for a central bar comes from astronomers looking for dark matter. Scientists working in two large collaborations, known as MACHO (Massive Compact Halo Objects) and OGLE (Optical Gravitational Lensing Experiment), have been looking at the galactic center for gravitational microlensing events, which occur when an object passes between Earth and a background star. The intervening object's gravity amplifies the light coming from the background star, allowing astronomers to detect a characteristic brightening and fading. When looking toward the east side of the galactic bulge, the MACHO and OGLE groups found that the frequency of microlensing events is significantly higher than predicted — indicating an overabundance of lensing stars in that direction. Once again, astronomers can easily explain the observations by invoking a bar that's pointing nearly in our direction.

A Peanut in Every Bar

Convinced of the bar's existence, astronomers are now concerned with determining its appearance, orientation, and stellar and gaseous components. This is proving to be extremely challenging. Aside from all the obscuring dust, our location within the galactic plane means that we see our galaxy edge-on rather than face-on. It's like trying to study the size and structure of a forest from deep inside rather than from an airplane.

An infrared image of our own galaxy, made with the Diffuse Infrared Background Experiment (DIRBE) aboard the Cosmic Background Explorer (COBE) satellite, reveals that the profile of the Milky Way's bulge is shaped like a peanut rather than a sphere. The DIRBE data also indicate that the long axis of the bar is angled between 10° and 30° from our line of sight to the galactic center. Astronomers attempting to assess the orientation of the bar using other methods have come up with estimates ranging from about 16° (based on models of molecular gas and neutral hydrogen gas motions), to 20° to 30° (based on the distribution of red-clump giant stars), to 45° (based on the distribution of certain Mira-type variable stars).

There is mounting evidence that all barred spirals have bulges shaped like sideways peanuts when viewed edge-on. It's an idea that Michael Merrifield of the University of Southampton in England and Konrad Kuijken of the

The Shape of the Milky Way

The bar is estimated to be about 12,000 to 18,000 light-years long, roughly one-sixth of the diameter of the Milky Way's disk. It is about two or three times longer than it is wide; in comparison, some barred spiral galaxies have bars five times longer than their width. Recent research suggests that a tightly wound spiral arm comes off each end of the bar, a phenomenon commonly seen in other barred galaxies. In the case of the Milky Way, the arms are so long that they reach to the opposite ends of the bar, forming a thin elliptical ring of stars and gas around the bar. The ring is a common feature of barred spiral galaxies and was confirmed by the work of Maartje Sevenster, a young Dutch astronomer now working in Australia. — *M.S.*

Kapteyn Astronomical Institute in the Netherlands call the "Snickers hypothesis," because "there are peanuts in every bar." Merrifield and Kuijken have been testing the hypothesis on the basis of the distinction between normal spirals and barred spirals when seen face-on. As astronomers first noticed decades ago, stars and gas trace circular orbits in the bulges of normal spirals, whereas stars and gas follow noncircular orbits in barred spirals. When Merrifield and Kuijken looked at edge-on galaxies, they found that galaxies with peanut-shaped bulges do indeed exhibit complex noncircular motions, whereas edge-on galaxies without peanut-shaped bulges have circular motions. Astrophysicists are just beginning to understand how the peanut-shaped bulges arise from the peculiar stellar orbits in galactic bars.

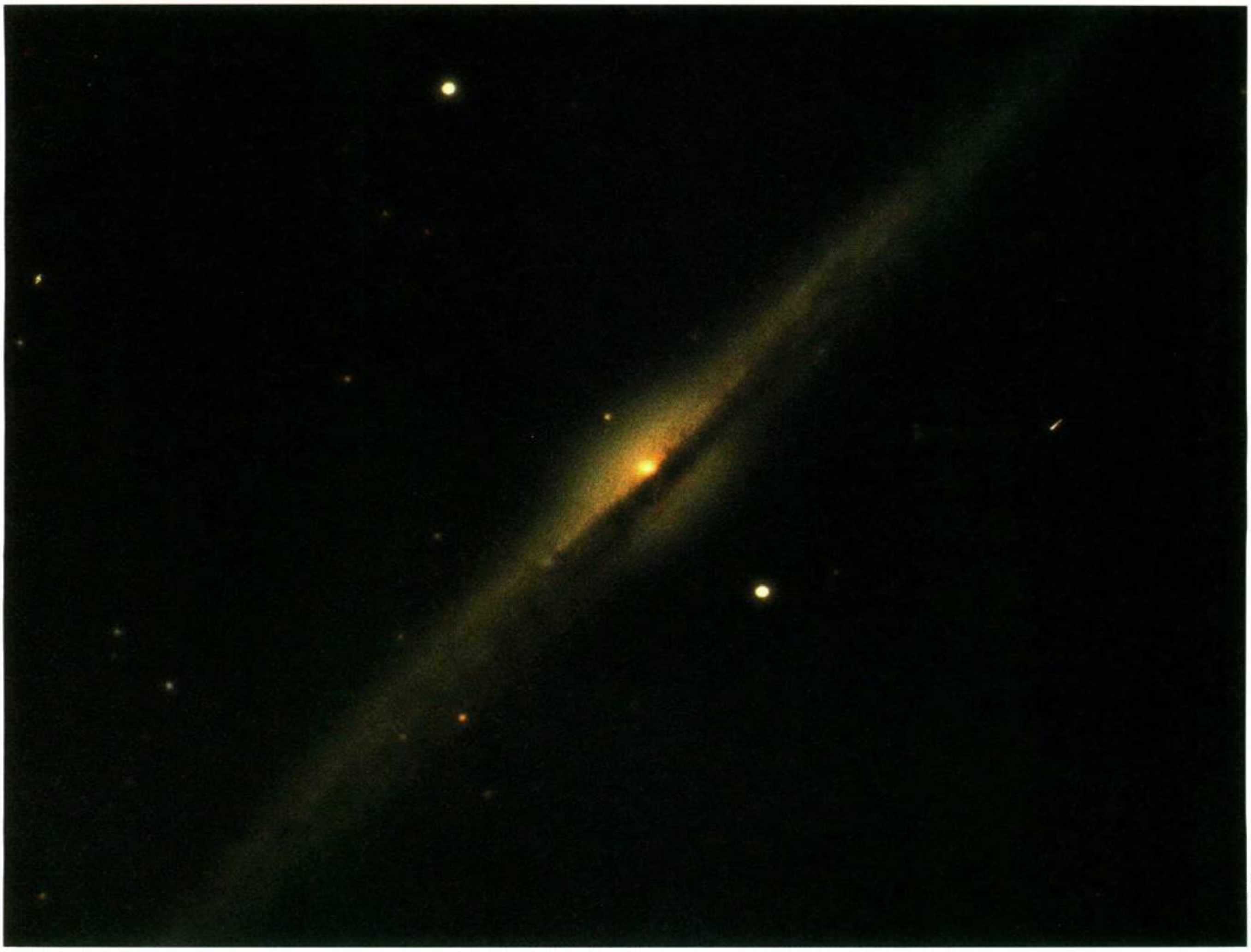
Astronomers are also studying whether various stellar and gaseous components have different distributions in the bulge and the bar. There is a good possibility that the Milky Way's bar has a specialized population of stars that has its own evolutionary history. As Dante Minniti of the MACHO collaboration has noted, "It is very important to disentangle the structure of the inner Milky Way using different stellar populations, because this is where most of the action occurred when the galaxy was forming."

For example, the bar is evident in the distribution of younger, metal-rich stars (i.e., stars with high abundances of elements heavier than hydrogen and helium). But not all of the stellar populations in the bulge are good tracers of the bar. Minniti and his colleagues have found that metal-poor RR Lyrae variable stars are not in a bar-like distribution. Because these stars are among the oldest in the galaxy (perhaps more than 10 billion years old), it suggests that the bar developed after these stars formed.

Action near the Bar

Having a central bar raises other questions about the evolution of the Milky Way, including the long-term dynamic effects of the bar. For example, despite the varied and peculiar motions of the individual stars within a galactic bar, the bar itself rotates as a solid structure — something like a large, slowly moving propeller. As the bar rotates, it tends to sweep up and collect any gas within the bulge (which is continually produced by aging and dying stars), sending it farther into the heart of the galaxy. This action has various consequences for large-scale activities in the bulge.

For one thing, the accumulation of all the gas in the bulge is believed to trigger intense periods of star formation — so intense that galactic bars may even be responsible for some huge outbursts of star birth in the cores of so-called starburst galaxies. The Milky Way is not a starburst galaxy as we now



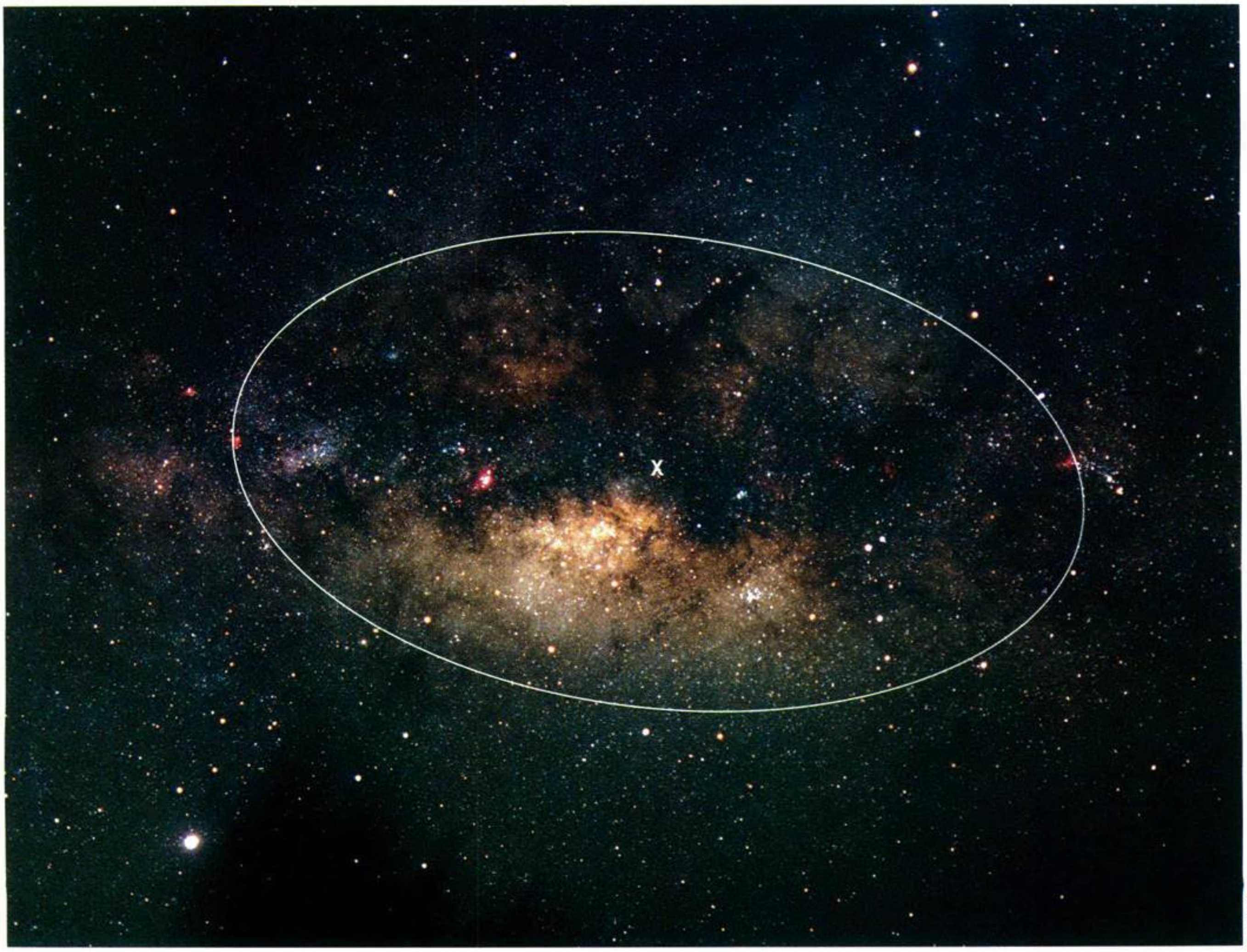
What would a barred spiral look like when seen edge-on? Because its bulge has a slight peanut shape, astronomers think this galaxy, NGC 4565, has a central bar.

U.S. Naval Observatory

observe it, but Michael Rich of Columbia University has noted that there have been periods of intense star formation in the past. In particular, some of the bulge's stars have a very high metal content, suggesting that several generations of stars must have died and scattered their inventory of heavy elements into space, where they were later incorporated into the metal-rich stars. In this regard, the galaxy's bar may have intensified the rate of star formation in the bulge. Indeed, the metal-rich population of stars in the bar observed by Minniti and others may partly be due to the sweeping action of the bar.

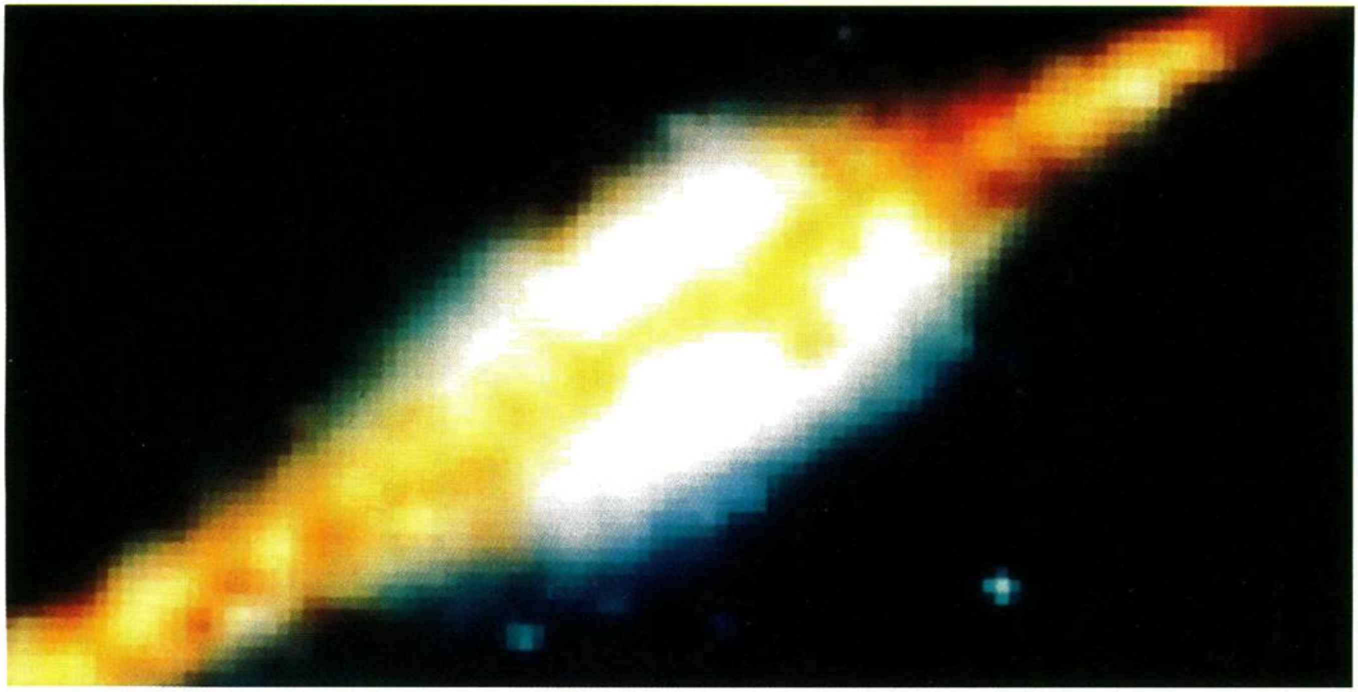
Some indication of starburst activity in our galaxy's past comes from the study of "truly amazing star clusters" near the galactic center by Don Figer and Mark Morris of UCLA and their colleagues. They found that some clusters contain as many as 20,000 solar masses, far greater than most young clusters in the galactic disk. Morris and Gene Serabyn of Caltech believe that

Tony and Daphne Hallas



Bob Hatfield

ABOVE: M81 is an ideal example of a "normal" spiral galaxy — one without a central bar. **BELOW:** This photo of the Milky Way in Sagittarius and Scorpius shows the location of the galactic center (X). The approximate location of the bar is highlighted in white.



NASA/Goddard Space Flight Center

An infrared image take by the DIRBE instrument on the COBE satellite shows that the Milky Way Galaxy's central bulge is shaped like a peanut, a trait indicative of barred spiral galaxies.

such extraordinary star formation has been taking place throughout the galaxy's lifetime and accounts for the strong, central concentration of stars. "Without the bar," says Morris, "star formation would not be nearly as frequent because there probably wouldn't be so much fuel (in the form of gas) concentrated there."

While the bar sweeps gas toward the center of the galaxy, the gas doesn't seem to make it all the way down to the core — where a two-million-solar-mass black hole reigns supreme. Because all large galaxies appear to have monster black holes in their cores, astronomers would expect barred spiral galaxies to have extremely bright nuclei, as material swept inward by the bar emits streams of radiation before plunging into their central black holes. But the Milky Way's central black hole is relatively quiescent, and barred spirals in general don't appear to have brighter cores than do normal spiral galaxies.

Jerry Sellwood of Rutgers University points to a ring of gas that circles the galactic center at a distance of about 1,000 light-years. "You get a pile up of gas at that point so the gas doesn't make it all the way to the center," he says. "Instead of flowing parallel to the bar, the gas starts flowing perpendicular. Once that happens, the gas doesn't want to go in any farther. If all of the gas that came in down the bar were to hit the central black hole, the Milky Way would have an incredibly spectacular active nucleus."

Morris and his colleagues also found what may be another consequence of the sweeping action of the bar: an extremely powerful magnetic field that is concentrated at the center of our galaxy's bulge. The magnetic field reveals itself in structures known as radio filaments that lie within 500 light-years of the galactic center and that extend as much as 100 light-years above and below the galactic plane. The radio filaments indicate that the magnetic field lines, which are almost a thousand times stronger than those in the sun's vicinity, are oriented as though a giant bar magnet pierced the heart of the galaxy perpendicular to the galactic plane.

According to Morris, the galactic bar could be largely responsible for the enormous strength of the central magnetic field because the gas it sweeps into the center carries a magnetic field with it, which then builds up over the lifetime of the galaxy. Morris suspects that astronomers will eventually find that barred spiral galaxies have stronger central magnetic fields than do normal spiral galaxies.

Astronomers and the Bar

All the activity in and around the bar has attracted astronomers to study the galactic bulge like never before. This is fortunate because it will take a new generation of investigators, using improved methods of looking at the center of our galaxy, to answer many of the questions raised by the discovery of the bar. Some of the most promising endeavors include an ongoing all-sky, high-resolution study in infrared light (the Two Micron All-Sky Survey, or "2MASS") and the next generation of OGLE studies, which will be looking at the distribution of large numbers of red-clump giant stars in the bulge. Both approaches should give astronomers a better idea of the size and shape of the central bar.

Fascination with the sheer majesty of the bar has also reclaimed astronomers who had temporarily left the subject behind. Blitz, who has been preoccupied with other projects since he and Spergel uncovered the bar, will soon return to studying the enormous structure at the hub of our galaxy. Reflecting on the bar's presence, Blitz mused, "It suggests that there are big things still to be discovered about the overall structure of galaxies and that one can still do it alone or in a small group. That is one of the things that makes astronomy particularly wonderful to its practitioners." ◼

Michael Szpir is an associate editor at American Scientist *magazine, where he writes and edits articles on astronomy and other sciences.*

NEUTRON STARS

The violent impact on Earth's atmosphere of a magnetar's blast of radiation gives birth to a new view of stellar evolution.

by Steve Nadis

ASTRONOMER THOMAS CLINE WAS THE FIRST to notice the magnetar's violent outburst. Theoreticians in Texas and North Carolina boldly suggested in 1992 that magnetars — magnetically powered neutron stars — exist. They proposed a mechanism that would produce such an explosive event, but they had to wait six years, until 6:22 A.M. EDT August 27, 1998, before one of these objects announced its presence so dramatically. At that moment a colossal, five-minute-long outpouring of gamma rays and x rays silently crashed into Earth's atmosphere, stripping electrons from atoms and leaving them electrically charged.

Fortunately, the event posed no health risk to people on the ground because the radiation's impact was absorbed by the ionosphere. Even though the intensity of the radiation there was far less than a patient would receive in a dental x ray, the event was historic. "This is the first confirmed example of a star beyond the sun affecting the Earth's atmosphere," says Stanford University atmosphere researcher Umran Inan.

Neither Cline, at the NASA Goddard Space Flight Center, nor any other astronomer realized what what had happened until the following day. On August 28, the Global Geospace (GGS)-Wind spacecraft transmitted the previous day's data to ground receivers. Data-analysis software, surveying the GGS-Wind data, detected the radiation spike. Following its pre-programmed orders, the software e-mailed the news to Cline, who sprang into action.

He e-mailed and telephoned astronomers who operate other x-ray satellites, who in turn contacted other astronomers and operators of ground-based atmosphere observatories. He dashed down Goddard hallways with a printout of the data in his hands and showed it to his colleagues. Like a dropped stone creating ripples in a pond, an expanding group of astrophysicists quickly scanned their data. They confirmed Cline's finding: On August 27, a "gigantic" surge of radiation had indeed swamped detectors on seven civilian astronomical spacecraft. Says Kevin Hurley at the University of California at Berkeley, "You could not have missed it."

By comparing the arrival times of the wave at each of the widely separated spacecraft, the source of the outburst was pinpointed — SGR 1900+14. SGR stands for soft-gamma repeater, and 1900+14 indicates the star's position in the sky, in hours and minutes of right ascension and degrees of declination. SGR 1900+14 had attracted interest in May and June 1998 when astronomers detected its emission of soft gamma rays.

SGRs, a type of neutron star first recognized in 1987, are intriguing because they sporadically emit bursts of gamma rays. These gamma rays are soft, meaning their energies lie in the lower end of the gamma range and upper end of the x-ray range. In contrast, gamma-ray bursts (GRBs), which astronomers discovered in 1973, contain higher-energy, or harder, photons. Gamma-ray bursts come from distant galaxies and appear randomly, from all directions in the sky. SGRs have been detected only in the Milky Way Galaxy and the neighboring Large Magellanic Cloud. Gamma-ray bursts also are brighter than SGR bursts and they do not seem to repeat from the same spot in the sky.

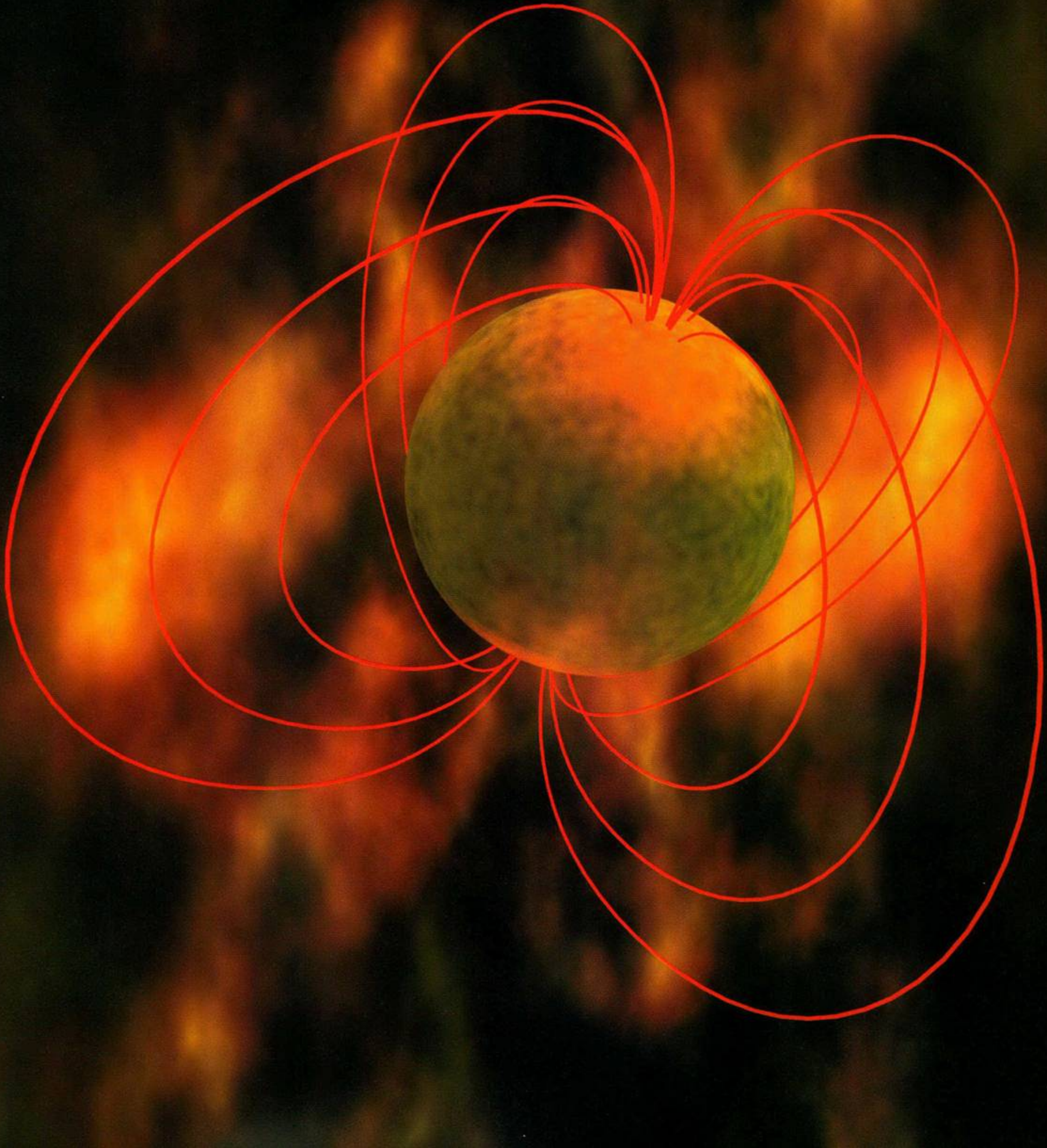
Luckily, Chryssa Kouveliotou, an astrophysicist at NASA's Marshall Space Flight Center in Huntsville, Alabama, had been observing SGR 1900+14 for several months prior to August 27. Using NASA's Compton Gamma Ray Observatory and the Rossi X-ray Timing Explorer (RXTE), she and her colleagues detected more than 50 flashes emanating from the pulsar in May and June 1998. Kouveliotou found that it was rotating like a lighthouse, emitting a pulse every 5.16 seconds. The pulses, moreover, showed a subtle but unmistakable pattern.

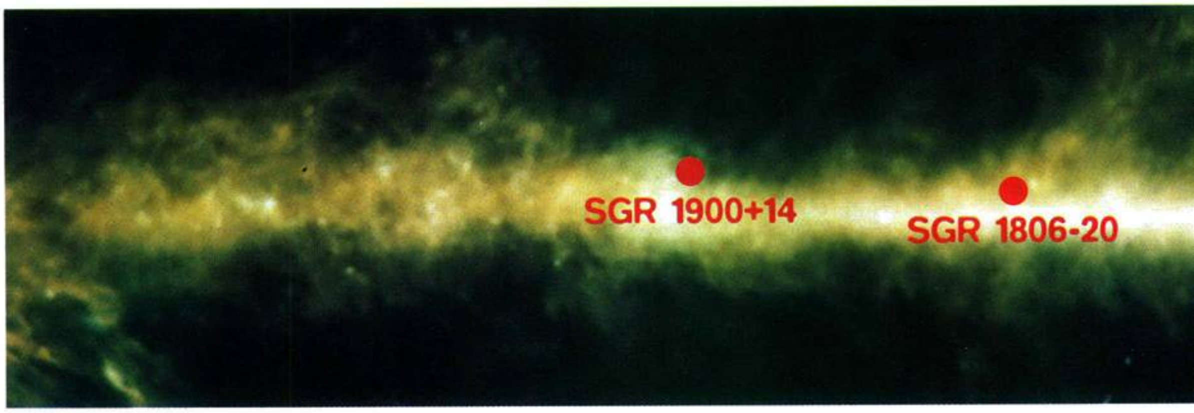
When Kouveliotou compared her measurements of SGR 1900+14 with those made previously by the Japanese-American Advanced Satellite for Cosmology and Astrophysics (ASCA), she discovered that the pulses had slowed slightly. She calculated that a powerful magnetic field, 800 trillion times the strength of Earth's, was acting like a brake on the spinning object. "A rotating magnet

Magnetars, neutron stars created by supernova explosions, have magnetic-field strengths 10^{15} times stronger than those of the sun.

Robert Mallozzi/University of Alabama, Huntsville/NASA

WITH ATTITUDE





The Milky Way is home to at least two known magnetars, but theorist Robert Duncan thinks a total of 1 million to 30 million may lurk in the galaxy.

emits electromagnetic radiation, and that energy comes at the expense of its kinetic energy," she explains. "The stronger the magnetic field, the more energy is carried away, the faster the star slows down."

In this case, the star has a magnetic field so powerful it must be a magnetar, Kouveliotou concluded, drawing on a theory advanced in 1992 by Robert Duncan of the University of Texas and Christopher Thompson of the University of North Carolina. Duncan and Thompson proposed that magnetars could form as the core of a massive star collapses and explodes in a supernova, leaving a neutron star in its center.

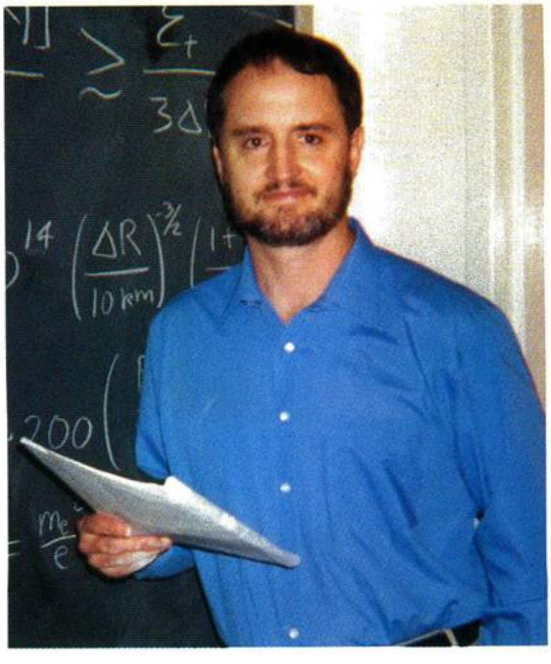
SOMETHING EXTRAORDINARY OCCURS during the first 30 seconds in the life of a neutron star. A pirouetting figure skater spins faster and faster as she draws in her arms and legs. Likewise, a neutron star spins faster and faster as its mass of neutrons collapses into an incredibly dense ball about 12 miles (19 km) in diameter. If the neutron star is spinning fast enough — at least 200 revolutions a second — intense magnetic fields will be generated, Duncan and Thompson maintain. This happens when the star's fluid interior transfers its kinetic energy, from both rotation and heat convection, to the magnetic field. This process creates an ultra-magnetized star.

A magnetar is weird by any standard. Its magnetic field is 100 times stronger than any observed elsewhere in the universe. These fields are so powerful they occasionally crack the magnetar's own crust, causing intermittent "starquakes" that spew out incredible amounts of energy. This scenario can explain the origin of the 50 flashes emitted by SGR 1900+14 during May and June. Far more explosive releases of energy are possible when a magnetar's magnetic field reorganizes itself and belches pure magnetic energy. After such a violent flare, like the one detected August 27, the magnetar's field jumps to a lower energy state.

Magnetars, according to Duncan and Thompson's theory, burst intermittently for about 10,000 years. After releasing vast amounts of energy during this time, they cool and their spinning slows. They then become tranquil and gradually fade from view.

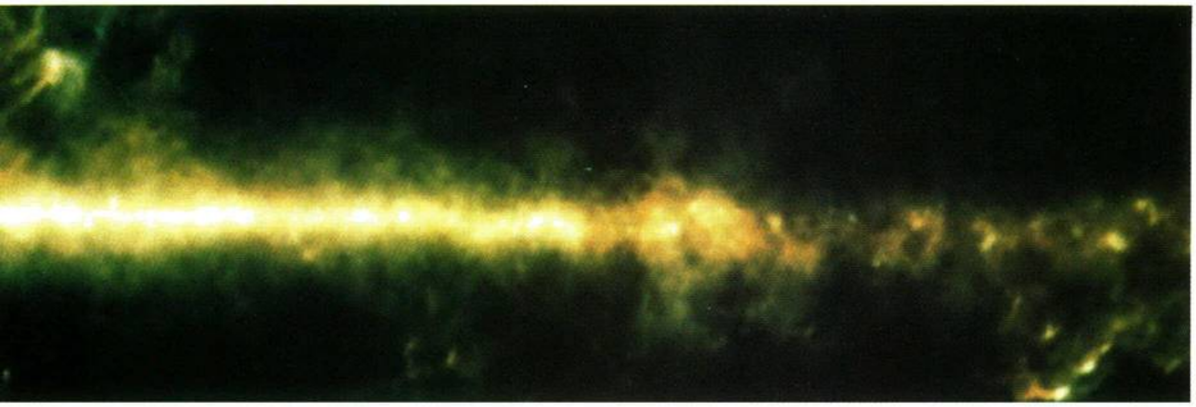
SGR 1900+14 is not the first magnetar discovered. Kouveliotou's team announced in the May 21, 1998, issue of *Nature* that it had discovered a magnetar — called SGR 1806–20 — in the Milky Way. Observations with ASCA and RXTE showed a slowdown in the neutron star's rotation, which implied a 800-trillion-gauss magnetic field. That value is 1,000 trillion times stronger than Earth's. It is roughly 1 million times stronger than that needed to kill humans instantly by rearranging all the atoms and molecules in their bodies. SGR 1806–20, which lies inside a supernova remnant less than 10,000 years old, has x-ray emissions that pulse once every 7.5 seconds — features that are consistent with Duncan and Thompson's magnetar model.

There are two other known soft-gamma repeaters (in addition to SGR 1806–20 and 1900+14) and possibly a third. (The latter gave off a few tantalizing bursts in 1997 and then went silent.) The emerging consensus among astrophysicists is that all SGRs are magnetars.



Robert Duncan advanced a theory in 1992 with colleague Christopher Thompson that magnetars could form as the core of a massive star collapses in a supernova explosion.

University of Texas



NASA

THE SIGNIFICANCE OF THESE RECENTLY found objects — assuming the existence of magnetars continues to be supported by additional observations — is enormous. "This points to a new branching of stellar evolution — a whole new path that a neutron star can take after a supernova explosion," says Duncan. A significant fraction of neutron stars could go this way, he adds, although figuring out the precise fraction is difficult.

How many SGRs might there be in addition to the four or five known ones in the Milky Way and Large Magellanic Cloud? "They are not subtle things you have to search hard for," Hurley notes. "When SGRs go off anywhere in the galaxy, they really jump out at you." But SGR 0526–66, which on March 5, 1979, produced the most energetic flare ever recorded, has been quiet since then. Nobody can say when it will erupt again. "That tells you there might be some SGRs in this galaxy that haven't burst yet," Duncan says.

Dale Frail, a radio astronomer at the National Radio Astronomy Observatory, says, "SGRs are not the only magnetars out there." He thinks the few discovered so far may be "the tip of an iceberg."

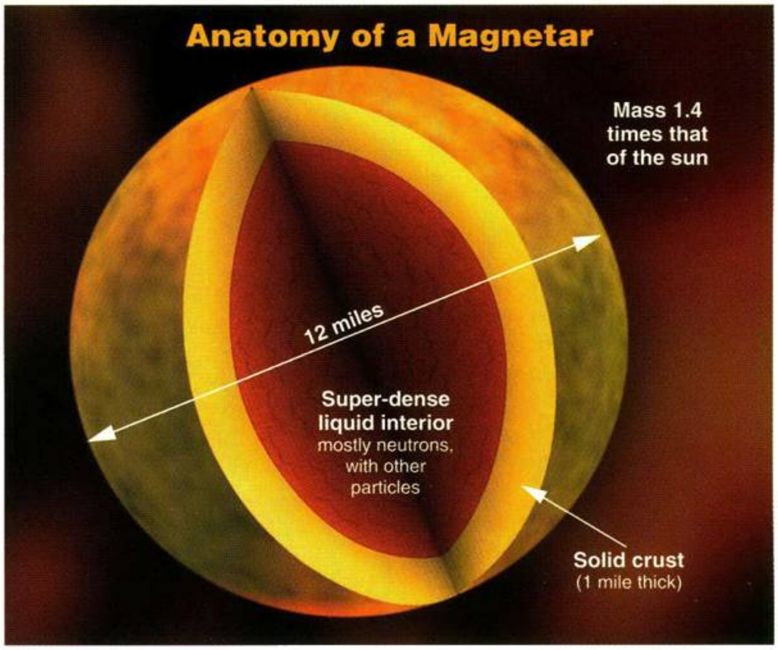
So-called anomalous x-ray pulsars (AXPs) — six of which have been found in the Milky Way — also could be magnetars. AXPs emit lower-energy photons than normal x-ray pulsars and astronomers have not seen any burst. However, based on the deceleration or "spin down" rate of AXPs, intense magnetic fields have been computed for several of them. Their rotation periods are usually between 6 and 12 seconds, whereas most x-ray pulsars have a much broader range of rotational speeds.

Since AXPs have magnetic fields as strong as SGRs, but usually longer periods, some astronomers speculate that as SGR magnetars spin down they may become AXP magnetars. Gautam Vasisht, an astronomer at the California Institute of Technology and the Jet Propulsion Laboratory, considers this explanation too simplistic. He doubted the standard explanation after he found an AXP magnetar that had formed much earlier in the life history of a neutron star. In 1997, Vasisht and his Columbia University colleague Eric Gotthelf reported the discovery of an AXP at the center of the supernova remnant called Kes 73. Vasisht and Gotthelf sifted through data collected by the ASCA and ROSAT space telescopes over a 10-year period to study the Kes 73 pulsar. Based on its rate of spin down, they determined the pulsar's magnetic field to be roughly the same as that of SGR 1806–20. (They estimated that the magnetic field strengths of two other AXPs are in the same range.) The Kes 73 pulsar may have been the first confirmed magnetar, although some astronomers believe that an even stronger case was made in 1998 for SGR 1806-20.

The most peculiar thing about the Kes 73 pulsar is its age: It is only 2,000 years old, far younger than any known SGR. Vasisht cannot explain how, or if, SGRs and AXPs are related. "Perhaps the AXP phase is longer and the SGR phase fits somewhere in the middle," he says. "Or maybe they are completely independent objects."

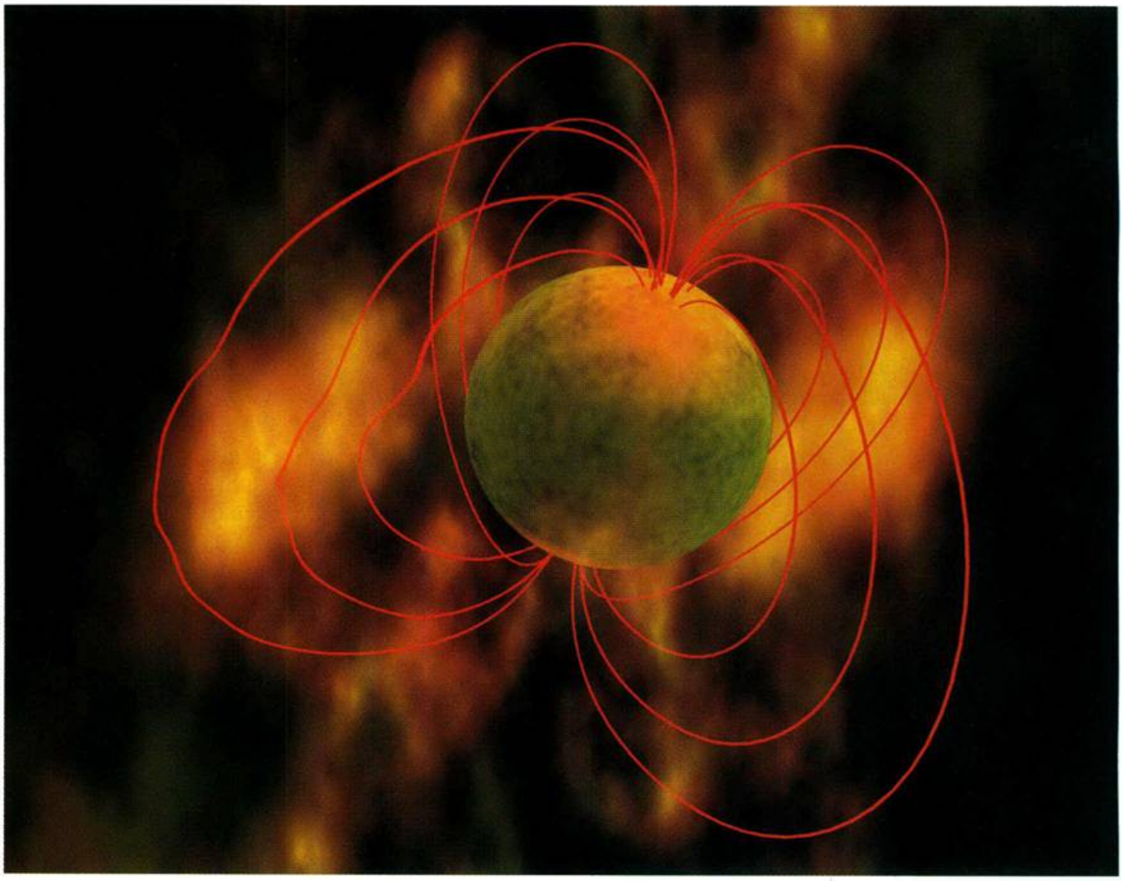
Duncan agrees that the picture is fascinatingly muddled. "AXPs could still burst," he says. "Although we haven't seen that happen yet, we can't entirely rule it out, which means that some AXPs might switch to being SGRs."

Some answers should come from the


Anatomy of a Magnetar
Mass 1.4 times that of the sun
12 miles
Super-dense liquid interior
mostly neutrons, with other particles
Solid crust
(1 mile thick)

Astronomy: Kellie Jaeger

Magnetic fields can become so powerful they often crack the magnetar's surface, and the resulting starquakes release huge amounts of energy.



Robert Mallozzi/University of Alabama, Huntsville/NASA

Advanced X-ray Astrophysics Facility (AXAF), which is scheduled for launch this year. Part of its mission is to discover AXPs. Until recently, Vasisht and Gotthelf had the field pretty much to themselves. "Now everyone else is plunging in," says Vasisht, adding that science should benefit from the discovery of more AXPs and SGRs. "Astronomy is based on studying populations of things. When we have a large sample, and have the chance to look longer at the objects and see what they do, the picture should become a lot clearer."

AXAF should also shed light on another class of x-ray-emitting neutron stars that lie in the center of supernova remnants. These objects have magnetic fields slightly below those measured for SGRs and AXPs, but well above those of standard radio pulsars. These as-yet-unnamed intermediary objects could also be magnetars, says Frail, who found that half of the 22 known supernova remnants he studied might be classified as magnetars of this sort.

ALL TOLD, DUNCAN ESTIMATES THERE may be 1 million to 30 million magnetars in the Milky Way Galaxy. But it is hard to arrive at an exact figure, he says, because these objects are invisible for most of their lives.

Observations from AXAF and other instruments will help astronomers conduct a more thorough census of magnetars in the Milky Way. Once researchers get better estimates of how many exist in our galaxy, they will be able to assess the probability of one being close enough to Earth to imperil life. The effects of the August 27 blast, for example, would have been a million times greater if the star had been 20 light-years away instead of 20,000 light-years distant. However, 20 light-years still might not be close enough to cause significant harm.

Duncan thinks a magnetar would have to be within one light-year of Earth to significantly deplete or destroy the ozone layer during a big flare. That's a remote prospect, given that the nearest known star, Alpha Centauri, is more than four light-years away. "This doesn't look like a good way of wiping out life here," Duncan says. A supernova explosion would pose a bigger threat, he adds, and could inflict significant damage from a distance of 30 light-years. But most astronomers believe asteroids and comets still pose the greatest threat.

At any rate, SGR 1900+14 should remind us that our planet is affected by more than just the sun, says Stanford's Inan. "Although much of astronomy is about seeing light from other stars, for a brief period of time, this star from halfway across our galaxy affected the atmosphere as intensely as our sun," he says. "That makes me realize that Earth is not in splendid isolation, as some may think." A

Steve Nadis writes about the stars from his sea-level perch in Cambridge, Massachusetts.

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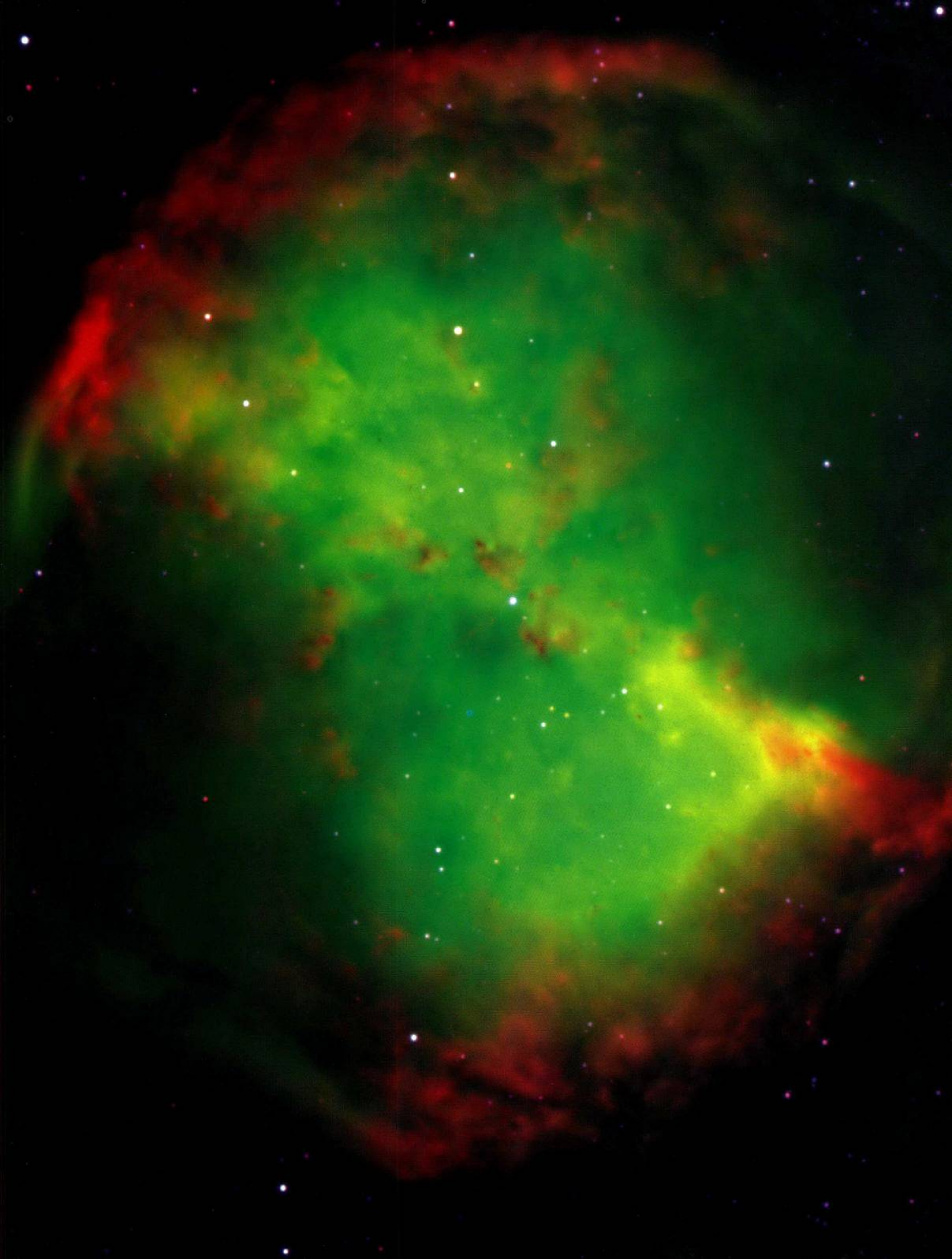


King of the MOUNTAIN

When completed early next century, Europe's Very Large Telescope will be the finest observatory in the world.

by Govert Schilling

On a dusty and bumpy road, I'm alone with the Atacama Desert. Some 30 miles south of the harbor city of Antofagasta, an inconspicuous road sign marks the intersection where I have left the busy four-lane Pan-American Highway. Now, my world turns into a silent, surrealistic mix of sun, rocks, and dirt. Only once during the 40-mile drive do I see an oncoming car, its presence signaled far in advance by a huge dust cloud on the horizon.

Hot and dry, the Atacama Desert in northern Chile is one of the most barren places on Earth. Nothing grows in this searing climate, where temperatures occasionally reach 100° F (40° C) despite the high altitude. Rock-strewn fields stretch all the way to the distant rolling mountains of the Cordillera de la Costa. In fact, the landscape bears such an eerie likeness to the Pathfinder photos of Mars that I almost expect to see the Sojourner rover emerging from behind a large boulder.

While the Atacama may be hell to most of us, it's an astronomer's paradise. The air is clean and dry with an average of 350 clear nights a year; some areas haven't seen a drop of rain for centuries. The seeing — a measure of the steadiness of the air — is superb. And since there are no towns or villages for dozens of miles, there's no light pollution. For these reasons, the European Southern Observatory (ESO) (see "Europe's Window on the Southern Sky," page 61), chose the Atacama Desert as the site for what will be the most powerful optical telescope in history.

Telescope for the 21st Century

After a long, shaky drive over pits and rocks, I understand why renting a car is so expensive in northern Chile. After nearly two hours, with a dry throat, a terrible sunburn, and rattling joints, I arrive at the foot of Cerro Paranal, home to ESO's Very Large Telescope (VLT). The impressive, 8,635-foot-high (2,632 meter) cone-shaped mountain has been beheaded with explosives to create a large plateau, where four identical 8.2-meter telescopes will work in unison to unravel the mysteries of the cosmos.

Not bad for a test image, eh? The first of the VLT's four 8.2-meter telescopes took this photo of the Dumbbell Nebula this past year.

The $500-million VLT is a project of superlatives. Each telescope alone would be world class. But taken together, the four telescopes will have a total light-collecting area equivalent to that of a 16.4-meter telescope, making them 70,000 times more sensitive than the first astronomical telescope, built four centuries ago by Galileo. The VLT will be 10 times more sensitive than the 5-meter (200-inch) Hale Telescope on Palomar Mountain in California and 2.5 times more sensitive than each of the twin 10-meter Keck telescopes on Mauna Kea in Hawaii. When working as an optical interferometer, the VLT will be able to see 50 times sharper than the Hubble Space Telescope. "If the VLT works as advertised, then leadership in a number of important areas of optical and infrared astronomy may pass from American astronomers to European astronomers," says John Bahcall of the Institute for Advanced Study in Princeton, New Jersey.

The first-light images from the first of the four monster scopes, Unit Telescope 1, were obtained last May. The images indicate that the VLT works even better than advertised (see "First Light for VLT," AstroNews, September 1998). After nearly a year of tests, Unit Telescope 1 will commence observing runs in April. In 2001, all four telescopes will be turned loose on the heavens.

The Paranal base camp, a scattering of sheds, primitive barracks that have been converted into offices, a large dining hall, and a number of technical buildings and laboratories, is literally a town in the middle of nowhere, housing a few hundred laborers. "Everything you see around you, down to the last nail, has been transported at least 75 miles (120 kilometers) from Antofagasta. Even the water is trucked in by four or five large tank wagons each day, and we have our own diesel-powered generator," says site manager Jörg Eschweij (pronounced Yerg Ash-why), a tall, bearded German, whom everyone calls "Mr. Paranal."

According to Eschweij, Paranal is much more remote than La Silla, some 370 miles (600 km) farther south, where ESO runs 15 telescopes, including the revolutionary 3.5-meter New Technology Telescope (NTT) (see "Enchanted City," June 1997). In the future, Paranal might well become one of the key astronomy centers in the Southern Hemisphere. "There are two more available peaks in the neighborhood," says Eschweij. "I wouldn't be surprised if someone would like to hook in on the existing infrastructure."

A safety officer drives me to the mountaintop, where he points out the Pacific Ocean a mere 7.5 miles (12 km) from the site and partially hidden from view by other mountains. The surrealistic landscape and the incredibly clear air provide few visual clues to estimate distances. The aluminum enclosures of the four VLT telescopes look deceptively close and small from the base camp. But in reality, it's a 2-mile (3-km) drive from the base camp to the summit, and the VLT is huge. Each enclosure measures nearly 100 feet (30 meters) high and 100 feet wide. I feel like I'm visiting the set of a science fiction movie.

The site bustles with construction activity. Safety helmets are compulsory; conversations are frequently drowned by the staccato noise of pneumatic drills. A gigantic crane towers high above one of the telescope buildings. Forklifts and concrete mixers are everywhere, and a bright yellow hydraulic platform just outside Unit Telescope 1 holds the 20-ton mirror cell with a dummy mirror made of concrete, ready to be lifted into the telescope.

The rehearsal with the dummy mirror, executed during my visit to Paranal in March 1998, went flawlessly, and six weeks later, the real mirror was put into place. Six weeks after that, the VLT opened its first eye on the universe and snatched its first photons. "First light for a telescope is like launching a ship," says Peter Gray, the British technician responsible for the integration of the mammoth telescopes. According to Gray, who has served on many large telescope projects, the Very Large Telescope is going to surpass the Keck telescopes in a number of ways. First of all, the total light-collecting area is nearly 40 percent larger. Second, the VLT has more operational flexibility, since it consists of four telescopes that can be used separately or together in a number of ways. Third, the planned instrumentation program is more ambitious, with a total of 11 state-of-the-art cameras and spectrographs to cover all wavelengths from near-ultraviolet to mid-infrared.

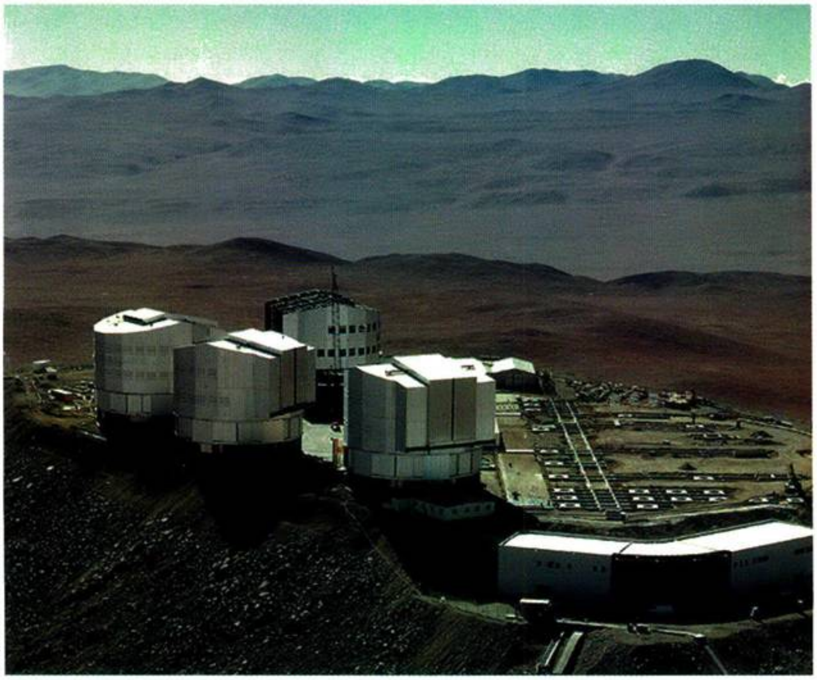
The true miracle of the VLT, however, lies in its mirrors — which are among the largest ever made. They're meniscus-shaped, like small pieces of an eggshell, and although they have a diameter of 8.2 meters (27 feet), they're only 7 inches (18 centimeters) thick. They are cast in a special rotating oven at Schott Glaswerke in Mainz, Germany, and polished to the highest standards at a special-purpose factory outside Paris. The mirrors are shipped to Antofagasta by boat, then transported to Cerro Paranal by truck over the unpaved desert road — a three-day trek at the slow pace of 3 miles (5 km) an hour.

The ultrathin mirrors are by no means stiff enough to maintain their desired shape (they would otherwise fracture under their own weight), so they have to be actively supported by 150 computer-controlled actuators. These actuators keep the mirror's surface in ideal shape, despite changes in tilt, temperature, and wind. In addition, the VLT will be equipped with an adaptive optics system to sharpen the view of celestial objects. Measurements of an artificial guide star, created high in the atmosphere by a laser, will be used to calculate the image distortions caused by atmospheric turbulence. A small, deformable mirror in the telescope's light path compensates for these distortions at a rate of 100 times per second.

Working as One

As I walk around the huge mechanical structure of Unit Telescope 1, I can't help

The four giant telescopes of the VLT rest atop 8,635-foot Cerro Paranal in northern Chile. The surrounding desert is one of the driest places on Earth.



All photos: European Southern Observatory being impressed by its sheer size. Still, this telescope is much more compact, relatively speaking, than "classical" giants like the 5-meter Hale Telescope. The first reason for this is the 22-ton (20-metric ton) mirror, which is light for a mirror of its size, and therefore doesn't require an extremely heavy mount. Second, the VLT telescopes, like all modern astronomical telescopes, have altazimuth mounts, with one vertical and one horizontal axis, rather than old-fashioned and voluminous equatorial mounts.

I imagine this giant slowly and silently moving with variable speeds around both axes, to track the nightly movement of the stars across Paranal's pitch-black sky — 470 tons (430 metric tons) of steel and glass, floating on an oil film 0.002 inch (0.05 mm) thick, and so well-balanced that it could be moved with the mere touch of a finger. This design was first tried on ESO's New Technology Telescope, which has served as a test bed for many of the VLT's technologies.

Later that day, I find myself beneath the Very Large Telescope, in the maze-like system of tunnels that connect the four telescope enclosures with the control room and with one another. Jason Spyromilio, a Greek infrared astronomer, points out the various cables and pipes. "This one is for electricity, that one is a data cable," he says. "The huge ones are part of the air conditioning system. The smaller tubes are for coolant. If you ever get lost here, just head in the direction where the number of cables increases — that will bring you right into the control room." During the day, the air conditioning system keeps the air inside the enclosures at the expected nighttime outside temperature, minimizing air turbulence and heat exchange when the giant steel doors are opened at sunset.

Spyromilio is a tall, cheerful man with a responsible task: He is head of commissioning, and since last May, he has been in charge of fine-tuning Unit Telescope 1 to the high standards of the astronomical community. He takes me to the 200-foot-long (60 meter) interferometer tunnel — a gloomy, quiet place,

The star forming region RCW38 falls under the gaze of Unit Telescope 1's infrared camera, which was installed on November 14, 1998.

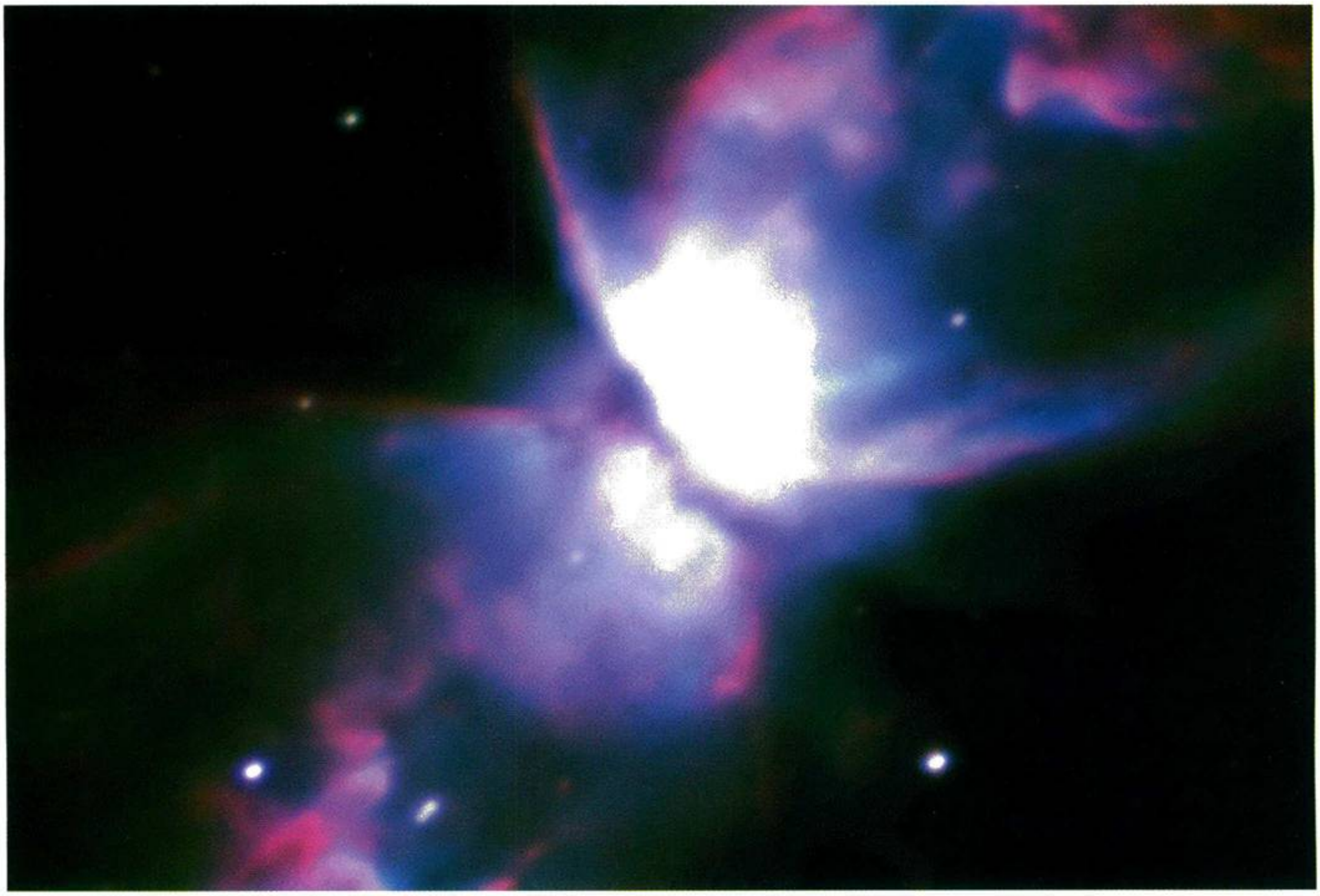
Europe's Window on the Southern Sky

The European Southern Observatory (ESO) was founded in 1962, on the initiative of Dutch astronomer Jan Oort of Leiden University. Oort was worried by the fact that European astronomers had no access to the southern sky, which harbors interesting objects such as the center of the Milky Way and the Magellanic Clouds.

No single European country could finance a large southern observatory, so an international consortium was established, comparable to CERN, the European center for particle physics. Currently, ESO has eight member states: Belgium, Denmark, France, Germany, Italy, the Netherlands, Sweden, and Switzerland. Each member state pays a contribution according to its gross national product. ESO's headquarters are located in Garching, a suburb of Munich, Germany.

Over the years, the consortium has built what is now the largest astronomical observatory in the world, judging by the number of telescopes. At Cerro La Silla, an 8,000-foot (2,400-meter) mountaintop 370 miles (600 km) north of Santiago de Chile, 15 telescopes spy on the sky each night, including the 15-meter Swedish-ESO Submillimeter Telescope and the revolutionary 3.5-meter New Technology Telescope.

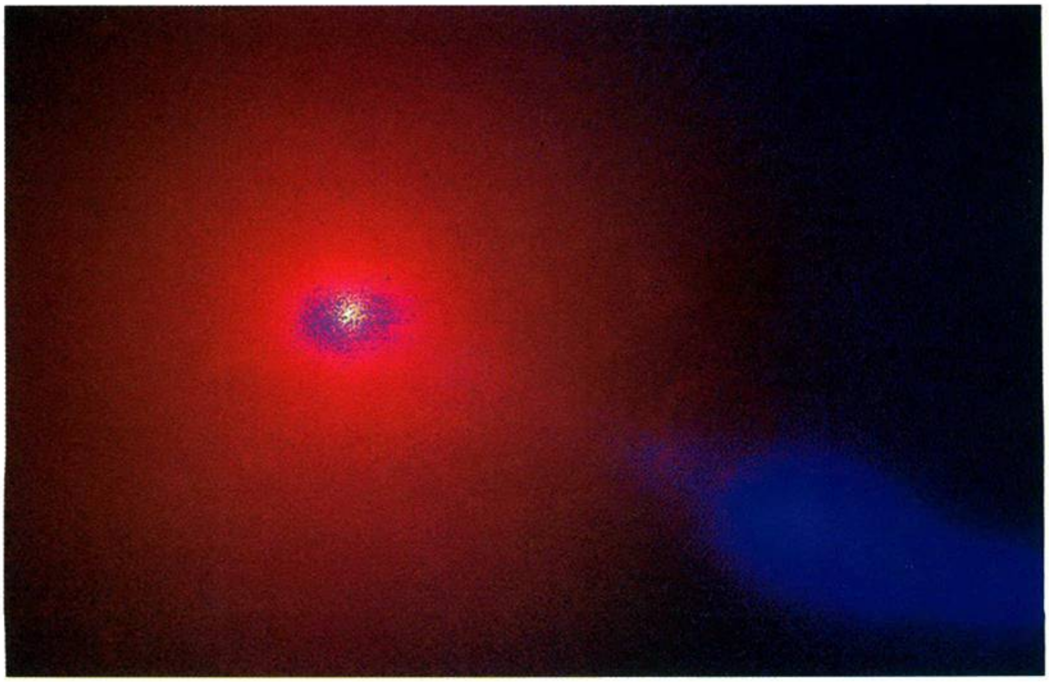
After completion of the Very Large Telescope on Cerro Paranal, ESO will embark on another major project, in close cooperation with the U.S. National Radio Astronomy Observatories: building a large interferometric array of millimeter-wave telescopes at an altitude of more than 16,000 feet (5,000 meters) in the Chilean Andes. — *G. S.*



Unit Telescope 1 imaged the Butterfly Nebula (above) and a powerful jet shooting out of the core of elliptical galaxy M87 (below).

well away from the activity outside. "I like to come here every now and then; it's so quiet and peaceful," he says. Early next century, this tunnel is where VLT magic will be wielded: as astronomers configure the four telescopes to work together as one to achieve the resolution of a 130-meter behemoth.

Interferometry is a technique whereby two or more telescope mirrors act as though they are parts of a single gigantic "virtual" mirror with a resolution equivalent to an imaginary telescope with an aperture as large as the distance between the individual mirrors. To achieve this, the light from the telescopes must



be brought together in phase, meaning the crests of the light waves coming from each telescope must arrive at the detector at exactly the same moment. Radio astronomers have used interferometry for more than 20 years. For example, the 27 dishes of the Very Large Array radio telescope in New Mexico can be spread apart on railroad tracks to resolve details that would normally be visible only to a 25-mile-wide (40 km) radio dish.

But infrared and optical interferometry are much more difficult to achieve than radio interferometry, because it's much easier to line up wave crests when the distances between them are measured in meters or centimeters (as in radio waves) than in nanometers (as in visible light). Unfortunately, astronomers can't just add up the light gathered by the four telescopes because a star's light waves will not reach the four telescopes simultaneously, and for interferometry to work, corrections have to be made for the slightly different distances that each light wave travels. This poses a challenge: At optical wavelengths, one has to know these differences to a precision of 0.000002 inch (0.00005 mm), and these distances are constantly changing as the telescopes track their celestial target.

The VLT interferometer tunnel will house the so-called delay lines, developed by Fokker Space in Leiden, the Netherlands. They consist of flat retroreflector mirrors, called cat's eyes, mounted on carriages that are driven by a motor along a system of 200-foot-long (60 meter) rail tracks. Light from one of the VLT telescopes enters the tunnel from one side, is reflected toward one of the mirror carriages, and is then reflected back again to the interferometry laboratory. The positions of the mirror carriages are changed continuously, to make sure that all light waves have traveled exactly the same distance before they're combined at the detector. Computer-controlled piezo crystals on the back of each mirror will compensate for rapid microscopic variations in light travel distances due to atmospheric turbulence or mechanical vibrations.

To achieve even better resolution, the VLT interferometer will use three additional 1.8-meter auxiliary telescopes that can be positioned at various locations. These relatively small telescopes don't add significantly to the VLT's total light-gathering power, but by increasing the number of baselines used for interferometry, the image quality improves dramatically.

The VLT's first interferometry observations will begin in 2002, using two of the 8.2-meter telescopes and two of the auxiliary telescopes. When the entire array is operating as an interferometer, starting around 2006, it will be able to resolve objects only 0.0005 arcsecond apart — meaning it could resolve an automobile's two headlights from a distance of 400,000 miles (about 1.7 times the distance between Earth and the moon).

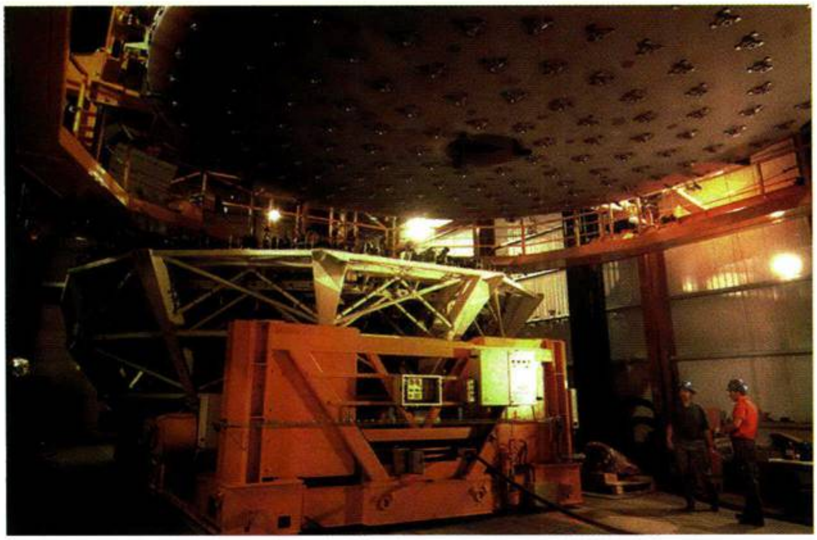
Cosmological Workhorse

Astronomers are excited about the possibilities the Very Large Telescope has to offer. Just like the Keck telescopes, the VLT will be a cosmological workhorse. With its huge light-gathering power, it will be able to scrutinize remote galaxies at the edge of the observable universe. "The VLT will permit us to study the very early universe," says Riccardo Giacconi, the first director of the Space Telescope Science Institute in Baltimore, Maryland, who is currently director-general of the European Southern Observatory. Giacconi is confident that the VLT will play a key role in solving the riddle of how galaxies formed.

The interferometric possibilities of the VLT will present astronomers with zoom-in views of the regions surrounding supermassive black holes in the cores of active galaxies. Right now, only the black hole in the center of our own Milky Way Galaxy can be studied in some detail, although observations at visible wavelengths are severely hampered by intervening dust clouds. However, the acute vision of the VLT Interferometer will reveal what's going on in the immediate surroundings of numerous other monster black holes.

Interferometry will also enable astronomers to image and study the protoplanetary disks around newly formed stars. These disks are thought to be the nursery rooms of extrasolar planetary systems. Extremely accurate measurements of star positions will probably reveal huge numbers of new extrasolar planets, which betray their existence by gently tugging

Unit Telescope 1 peered deep into space to capture this galaxy cluster. When all four 8.2-meter telescopes are completed, the VLT will take astronomers to the edge of the visible universe.



at their parent star. According to extrasolar planet hunter Michel Mayor of the Geneva Observatory in Switzerland, co-discoverer of the 51 Pegasi planet, the VLT Interferometer might even be able to directly image Jupiter-size planets around nearby stars.

When completed, the VLT will be the most powerful observatory in the world, and with its diverse collection of astronomical detectors, including high-resolution electronic cameras and multi-object spectrographs, it will help astronomers answer their most fundamental questions about the origin, evolution, and structure of the universe. Undoubtedly, this revolutionary instrument will also pose new questions and present new mysteries, keeping curious scientists busy in their endeavor to understand the universe

Handle with care: Each of the VLT's four 8.2-meter mirrors weighs 22 tons, but is only 7 inches thick.

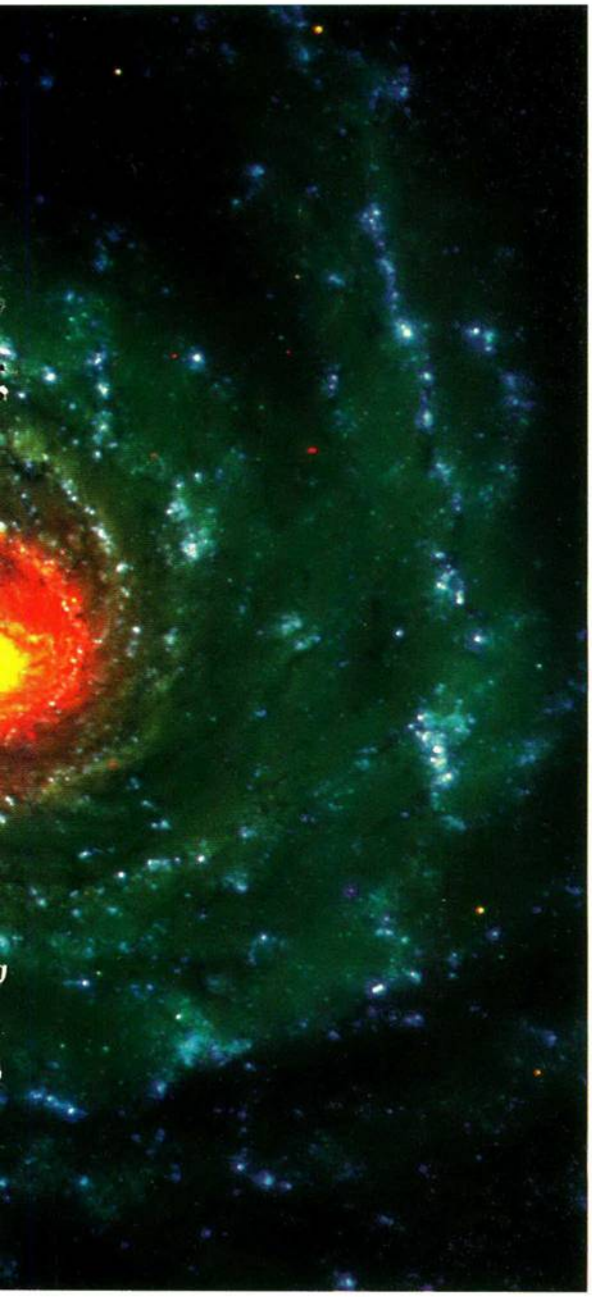
You ain't seen nothin' yet. This photo of spiral galaxy NGC 1232 was taken with just one of the four VLT scopes. Images taken after 2006, when all four telescopes are completed and working together as an interferometer, will be considerably sharper.

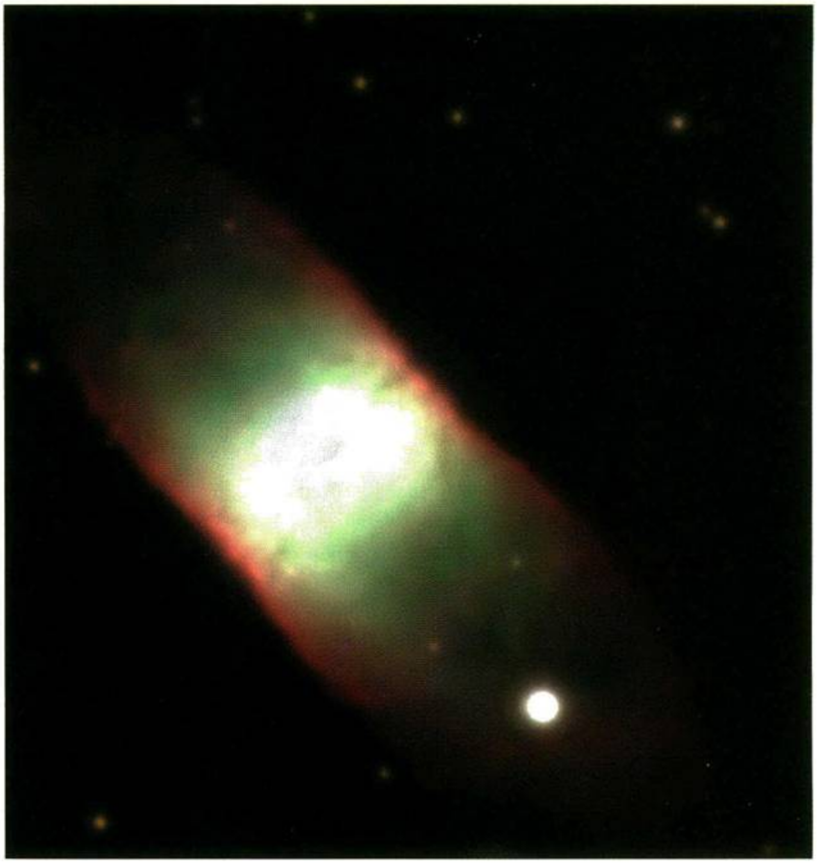
they live in — a quest that started thousands of years ago with humanity's first puzzled gaze upon the night sky.

New Vistas

In the early evening, I head for the top of a low hill, just outside the base camp, which itself is already engulfed by Cerro Paranal's shadow. A bank of clouds, hanging low above the Pacific, hides the borderline of sky and ocean from view. The aluminum enclosures of the Very Large Telescope shine like orange beacons, reflecting the last rays of the setting sun. Dark shadows crawl silently across the eerie landscape, and the heat of the day gives way to the chill of the desert night.

Soon, the western sky turns into a vivid display of rainbow colors, while in the east, Earth's shadow climbs higher and higher. Sirius and Canopus are easily visible; Orion and the Southern Cross follow suit. Half an hour later, the full splendor of the night sky is upon me, and I gaze across thousands of light-years to distant star clouds in the Milky Way, and far beyond, into the dark voids of deep space. The impact of the night sky hasn't changed over the millennia.





This Unit Telescope 1 image captures planetary nebula IC 4406. All the images in this article were taken at Unit Telescope 1 during its 1998 testing period.

ESO's Very Large Telescope is minuscule compared to the vastness of the universe it will study — four tiny specks of glass, catching just a few of the myriad photons that reach our planet, itself a little pebble orbiting an inconspicuous star in the outskirts of a run-of-the-mill galaxy. There's just too much universe out there for humanity to explore, and we'll probably never learn all there is to know. But the Very Large Telescope will expand our horizon tremendously. Just how much closer this will bring us to unraveling the cosmos? Only time will tell. ◼

Govert Schilling (goverts@knoware.nl) writes about astronomy from his home in Utrecht, the Netherlands. He has written nearly 20 books on astronomy in his native Dutch and has written for Astronomy, Science, New Scientist, *and a large number of Dutch newspapers and magazines. One of his most recent books, written in Dutch, is about the search for planets outside the solar system.*

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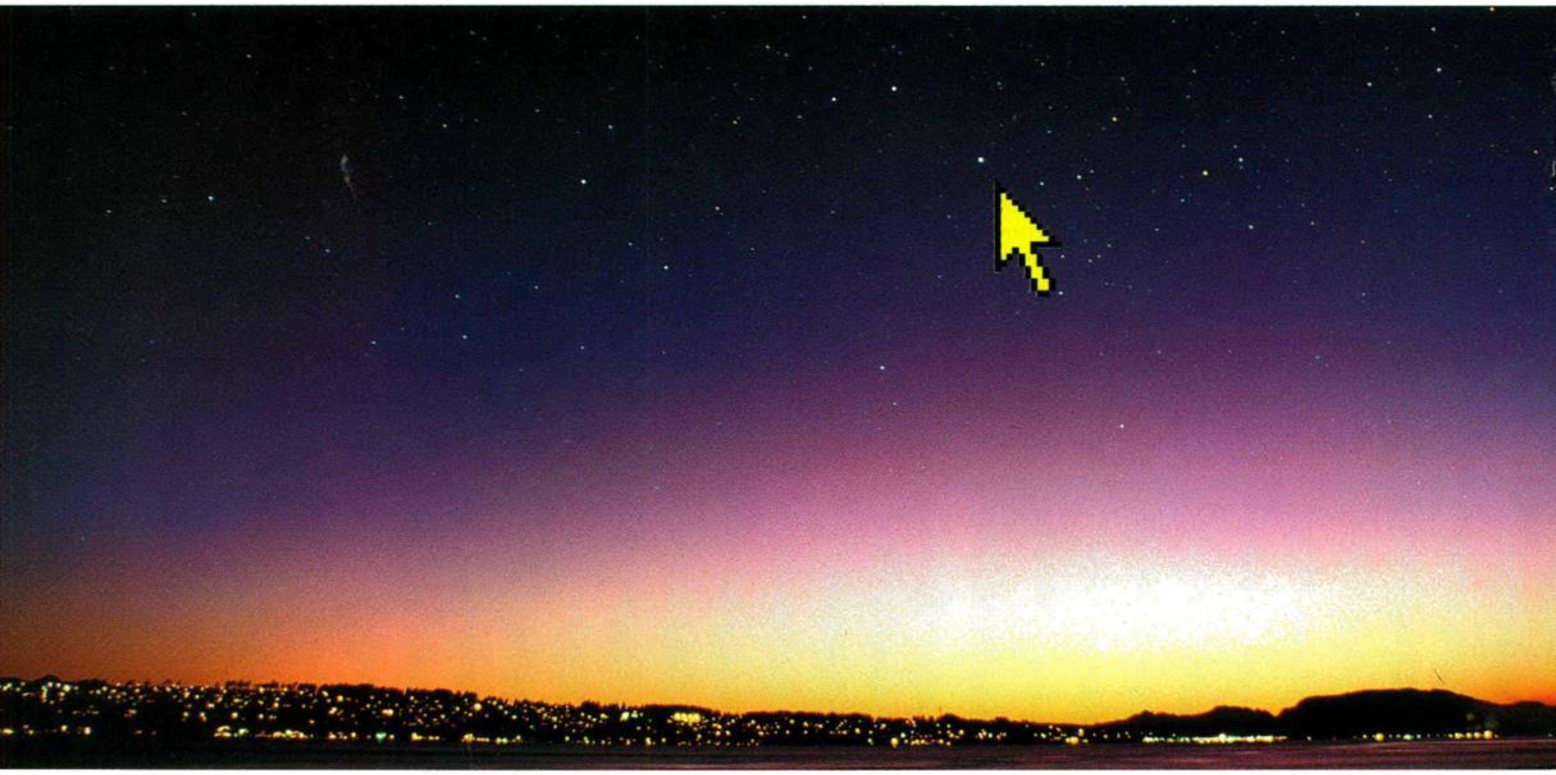

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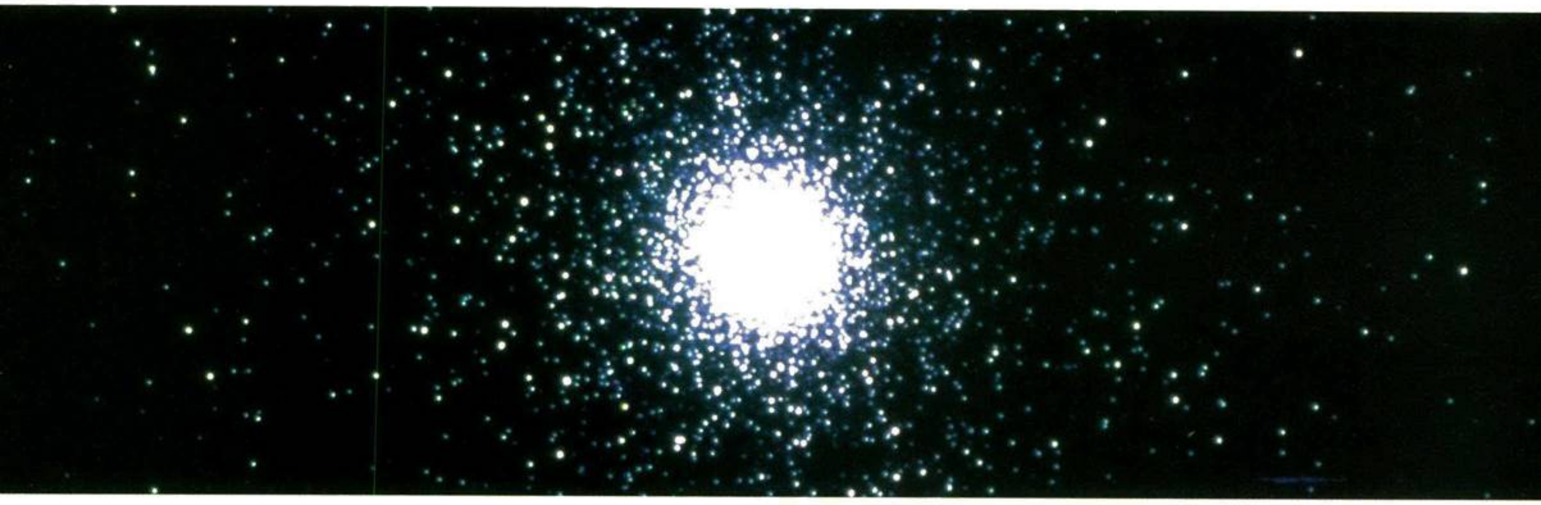
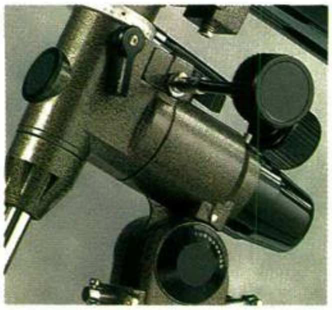


Globular Star Cluster photo courtesy of NOAO.

But it can be stabilized.



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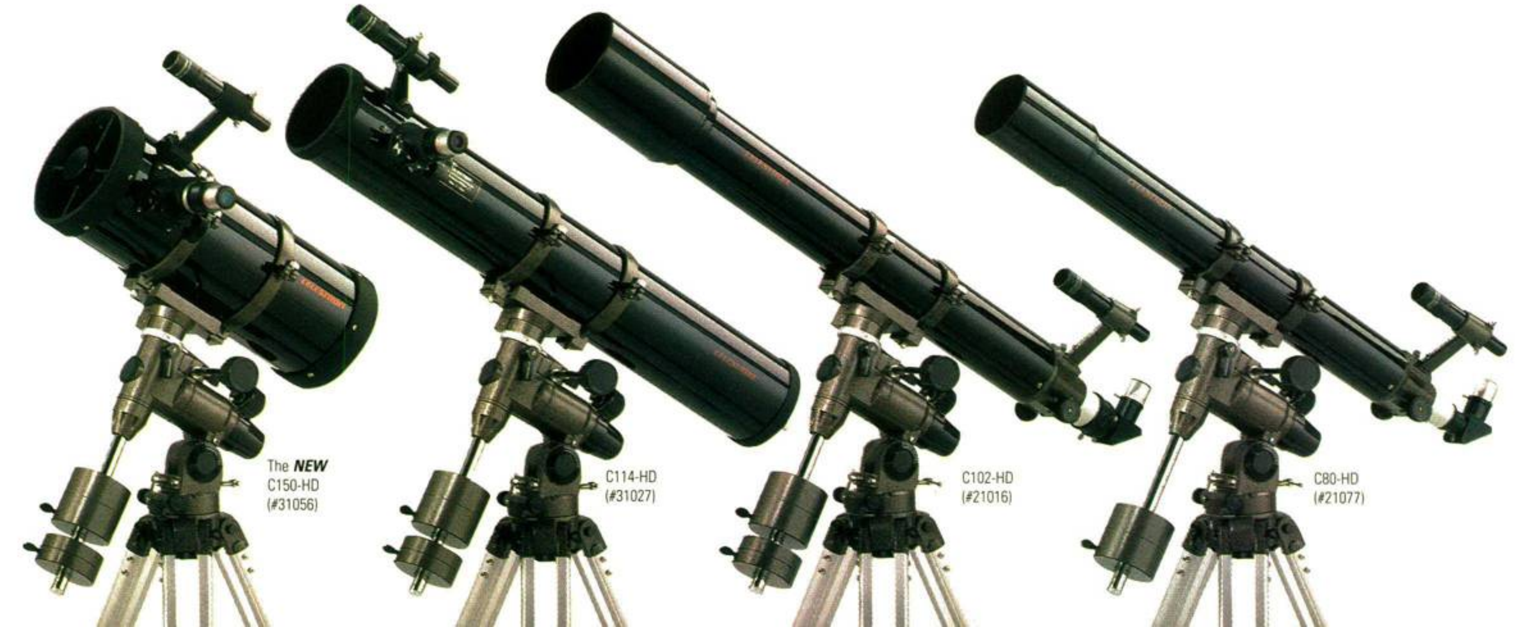
Finderscope	6x30	6x30	6x30	6x30
Accesories	Premium 20mm Plössl 1 1/4" eyepiece	Premium 20mm Plössl 1 1/4" eyepiece	Premium 20mm Plössl 1 1/4" eyepiece	Premium 20mm Plössl 1 1/4" eyepiece
Weights	29 lbs.	36 lbs.	28 lbs.	41 lbs.



THE SKY SHOW

The planets continue their spring show as Venus meets Saturn, and Mercury climbs toward Jupiter.

by Martin Ratcliffe and Alister Ling

March opens with a beautiful line of three planets above the western horizon. Venus is the highest and the most brilliant. Jupiter lies below Venus, while elusive Mercury is to the lower right of Jupiter during the first week of March.

Early March is the best time all year to see **Mercury**. It can be found roughly 11° above the western horizon 30 minutes after sunset. The planet sets only one and a half hours after the sun, so look for it early in the evening. As a guide use Jupiter, it's only 4° above and to the left (east) of Mercury.

On March 1, Mercury shines at magnitude –0.7. It changes rapidly during the month, dimming by nearly 0.2 magnitude per day. By March 10, it's at magnitude 1.1. This rapid fading is common after Mercury reaches its greatest eastern elongation (18° on March 3). It also makes seeing the planet more difficult.

Although Mercury seems to be near **Jupiter**, in reality the speedy planet is moving to our side of the solar system. Jupiter is on the far side of the sun — some 5.9 astronomical units away. Each evening Jupiter sets roughly three minutes earlier than the previous night. By the end of the month, Jupiter is lost in the solar glare.

Magnitude –4.0 **Venus** is still pulling away from the sun. It rises higher each night as it moves toward a meeting with **Saturn** on March 20. Watch Venus's nightly progress as it closes in on the ringed planet. The 20° separating the two on March 1 shrinks to only 3° by March 20.

Not only is the distance between Venus and Saturn shrinking, but Venus's phase is getting smaller as well. From March 1 to its meeting with Saturn on March 20, the gibbous phase shrinks by roughly 8 percent. This phase decrease is partially compensated with a gentle growth in the apparent size of the planet's disk — 13" at month's end. By June, its apparent size will have dou-

Evening commuters will gawk at Venus and the moon shining in the western sky. Here the pair gleams over "Big Sky Country."

John McNeal

MARCH 1999

1 The moon passes 0.2° north of Regulus, 5 A.M. EST

2 Full moon is at 1:58 A.M. EST

3 Mercury is at greatest eastern elongation (18°), 8 A.M. EST

6 The moon passes 3° north of Mars, 9 P.M. EST

8 The moon is at apogee (251,501 miles from Earth), 12:09 A.M. EST

10 Last quarter moon is at 3:40 A.M. EST

13 The moon passes 1.4° north of Neptune, 6 P.M. EST

14 The moon passes 1.3° north of Uranus, 3 P.M. EST

17 New moon is at 1:48 P.M. EST

18 Mars is stationary, 5 A.M. EST
The moon passes 3° south of Jupiter, 6 A.M. EST

19 Mercury is in inferior conjunction, 2 P.M. EST
The moon is at perigee (225,724 miles from Earth), 7:16 P.M. EST
The moon passes 5° south of Venus, 8 P.M. EST
The moon passes 3° south of Saturn, 10 P.M. EST

20 Venus passes 3° north of Saturn, 4 P.M. EST (page 74)
Vernal equinox is at 8:46 P.M. EST

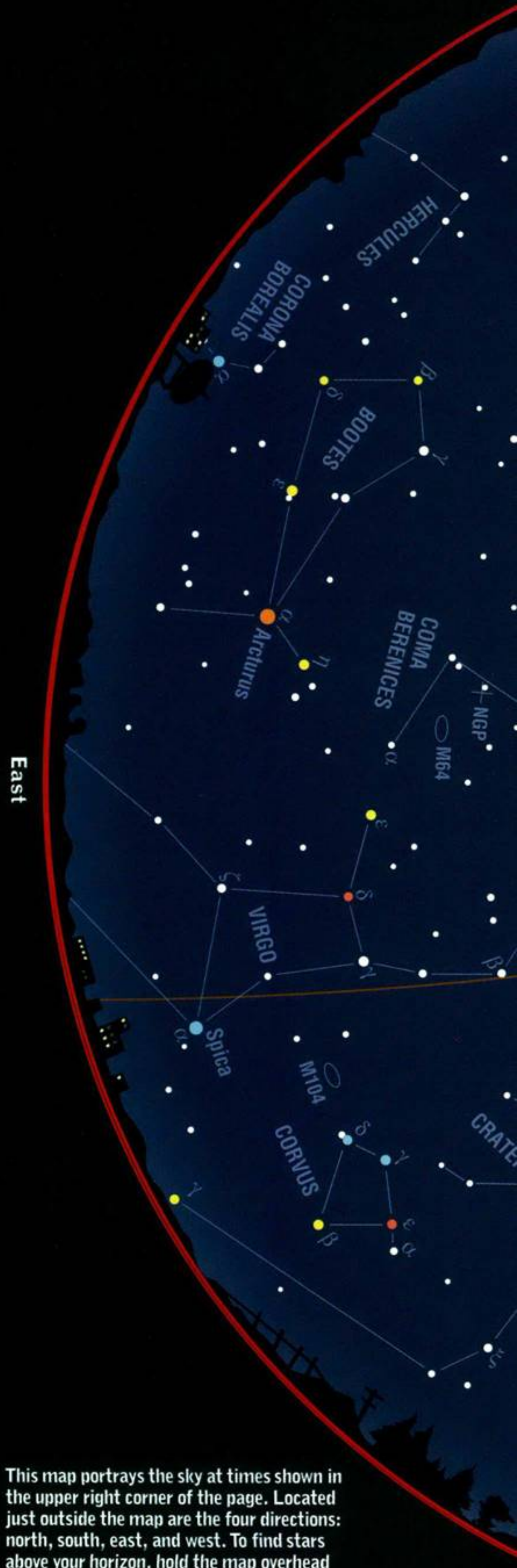
22 The moon passes 0.6° north of Aldebaran, 1 P.M. EST

24 First quarter moon is at 5:18 A.M. EST

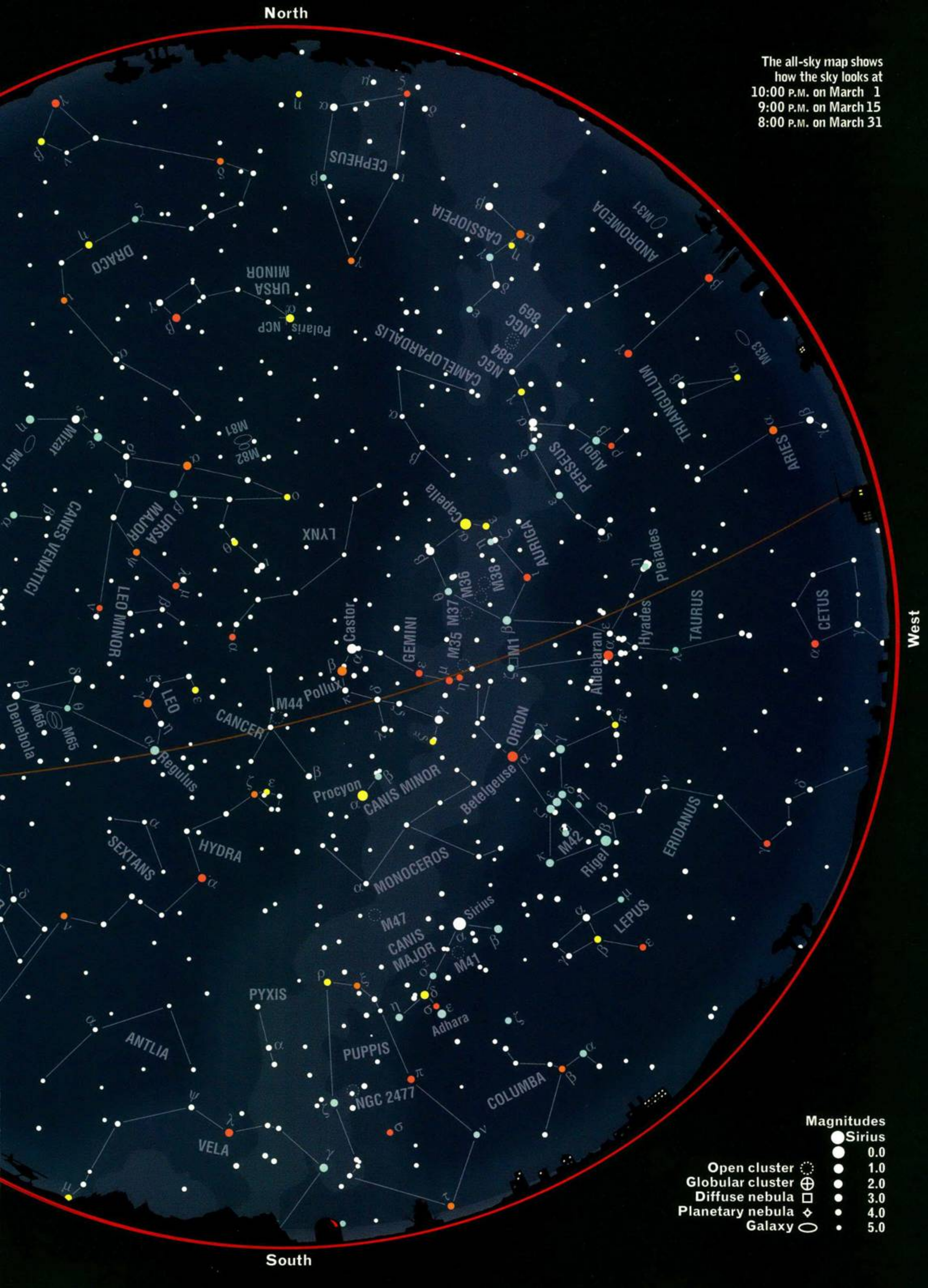
28 Asteroid Flora is at opposition, 8 A.M. EST
The moon passes 0.3° north of Regulus, 11 A.M. EST

31 Full moon is at 5:49 P.M. EST

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1 🌕	2 🌕	3 🌕	4 🌕	5 🌕	6 🌕
7 🌖	8 🌖	9 🌖	10 🌗	11 🌘	12 🌘	13 🌘
14 🌘	15 🌘	16 🌘	17 🌑	18 🌑	19 🌒	20 🌒
21 🌒	22 🌒	23 🌒	24 🌓	25 🌔	26 🌔	27 🌔
28 🌕	29 🌕	30 🌕	31 🌕			



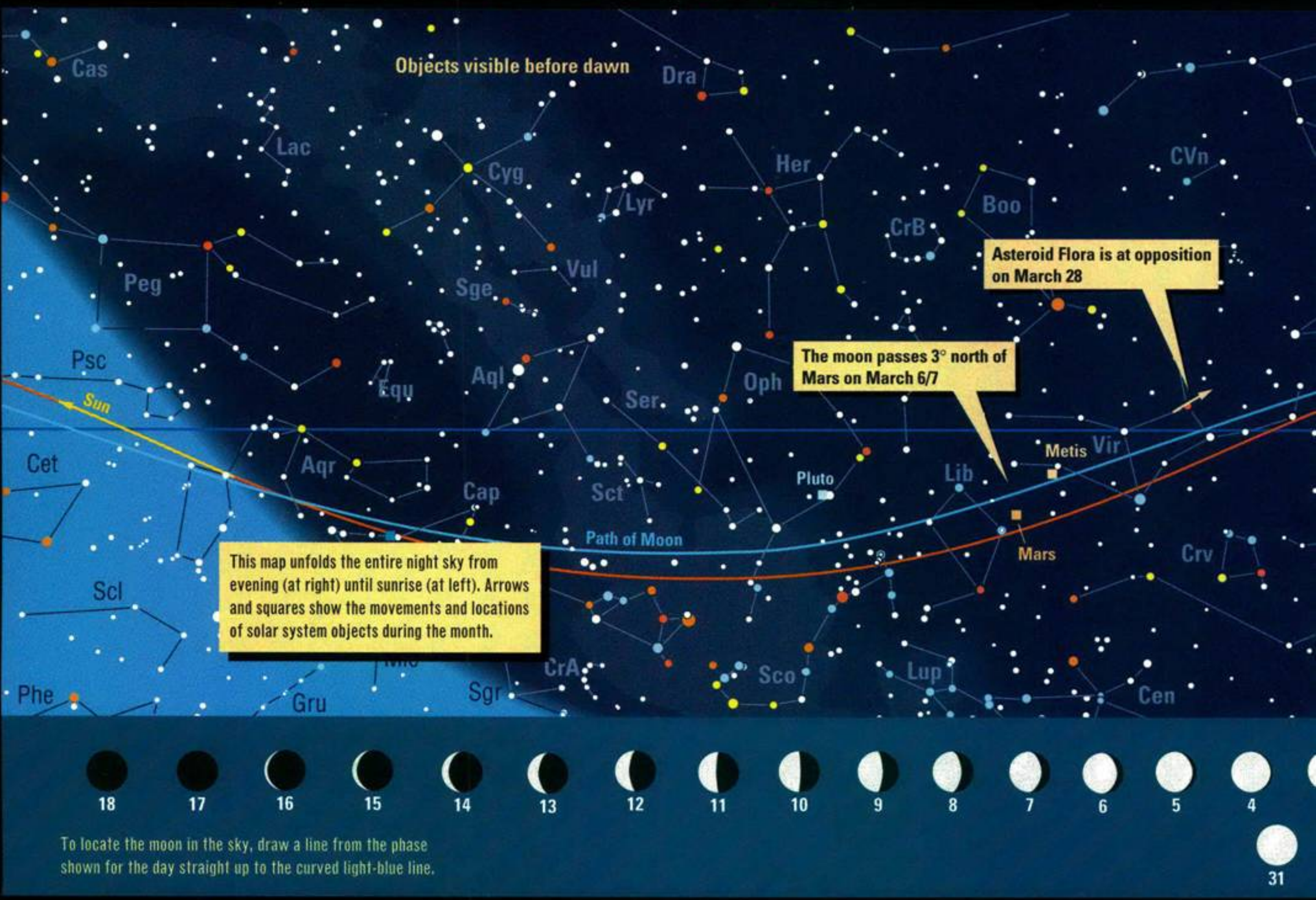
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



The all-sky map shows
how the sky looks at
10:00 P.M. on March 1
9:00 P.M. on March 15
8:00 P.M. on March 31

North
South
West
CEPHEUS
CASSIOPEIA
ANDROMEDA
M31
DRACO
URSA MINOR
Polaris
NCP
CAMELOPARDALIS
NGC 869
NGC 884
M33
TRIANGULUM
ARIES
PERSEUS
Algol
M81
M82
Mizar
M51
CANES VENATICI
URSA MAJOR
LYNX
Capella
AURIGA
M36
M38
M37
M35
M1
Pleiades
Hyades
TAURUS
CETUS
Aldebaran
LEO MINOR
Castor
GEMINI
Pollux
M44
CANCER
LEO
Denebola
M66
M65
Regulus
ORION
Betelgeuse
Procyon
CANIS MINOR
M42
Rigel
ERIDANUS
SEXTANS
HYDRA
MONOCEROS
M47
Sirius
CANIS MAJOR
M41
LEPUS
PYXIS
Adhara
ANTLIA
PUPPIS
COLUMBA
NGC 2477
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Cas
Objects visible before dawn
Dra
Lac
Cyg
Lyr
Her
CVn
Boo
CrB
Peg
Sge
Vul
Psc
Sun
Equ
Aql
Ser
Oph
Cet
Aqr
Cap
Sct
Pluto
Lib
Metis
Vir
Path of Moon
Mars
Crv
Scl
CrA
Sco
Lup
Cen
Phe
Gru
Sgr
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
31

Asteroid Flora is at opposition on March 28

The moon passes 3° north of Mars on March 6/7

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

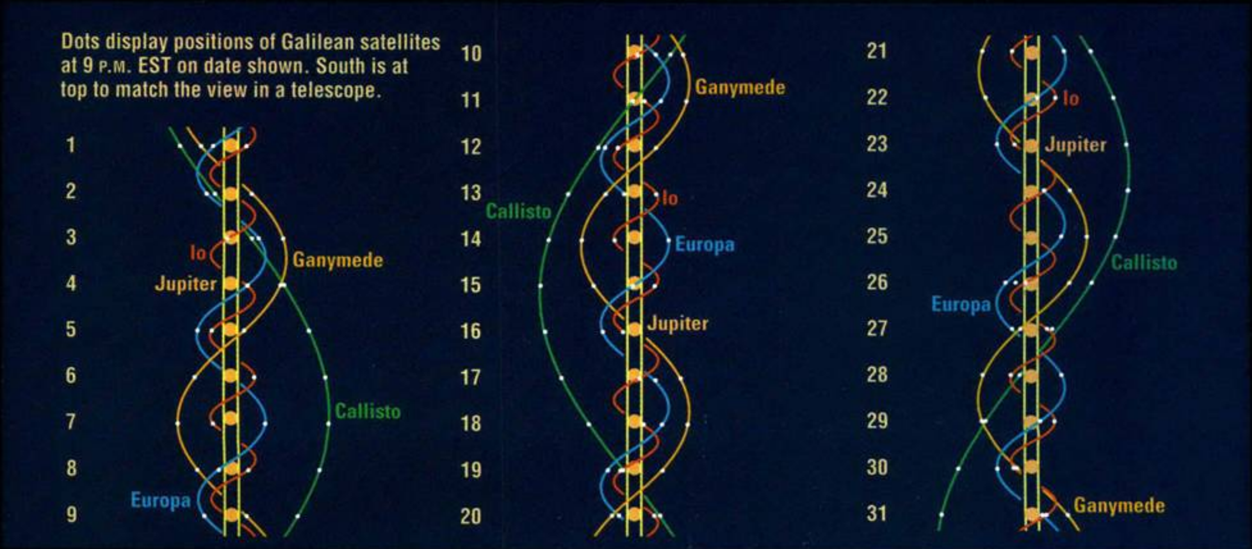
10"

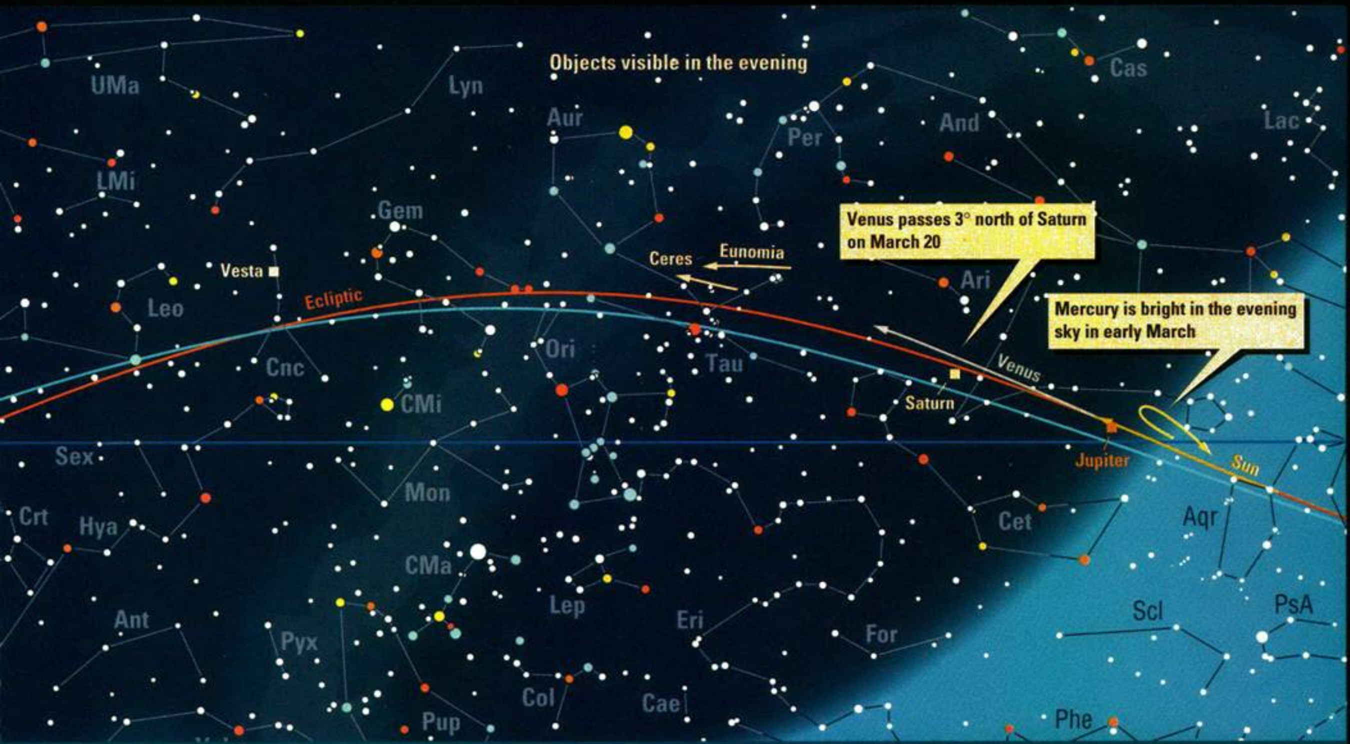
S
W — E
N

PLANETS	MERCURY	MERCURY	VENUS	MARS	MARS
Date	March 1	March 31	March 15	March 1	March 31
Magnitude	–0.7	1.8	–4.0	–0.2	–1.0
Angular Size	6.8"	10.4"	12.5"	10.3"	13.9"
Illumination	58%	16%	84%	93%	97%
Distance (AU) from Earth	0.995	0.644	1.337	0.907	0.676
Distance (AU) from Sun	0.308	0.440	0.721	1.639	1.614
Right Ascension (2000.0)	23h50.0m	23h26.1m	1h36.2m	14h35.0m	14h37.8m
Declination (2000.0)	0°05'	–2°42'	9°53'	–12°53'	–13°17'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 9 P.M. EST on date shown. South is at top to match the view in a telescope.

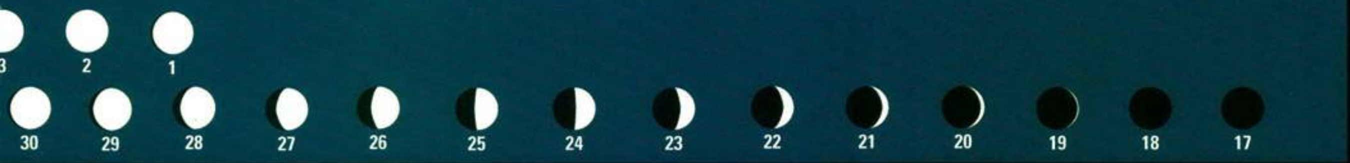



UMa
Lyn
Cas
Aur
Per
And
Lac
LMi
Gem
Ceres
Eunomia
Vesta
Ari
Leo
Ecliptic
Cnc
Ori
Tau
Venus
CMi
Saturn
Jupiter
Sun
Sex
Mon
Crt
Hya
Cet
Aqr
CMa
Ant
Lep
Eri
Scl
PsA
Pyx
For
Col
Cae
Pup
Phe

Objects visible in the evening

Venus passes 3° north of Saturn on March 20

Mercury is bright in the evening sky in early March


3
2
1
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28
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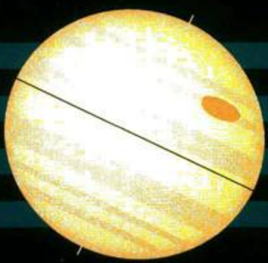
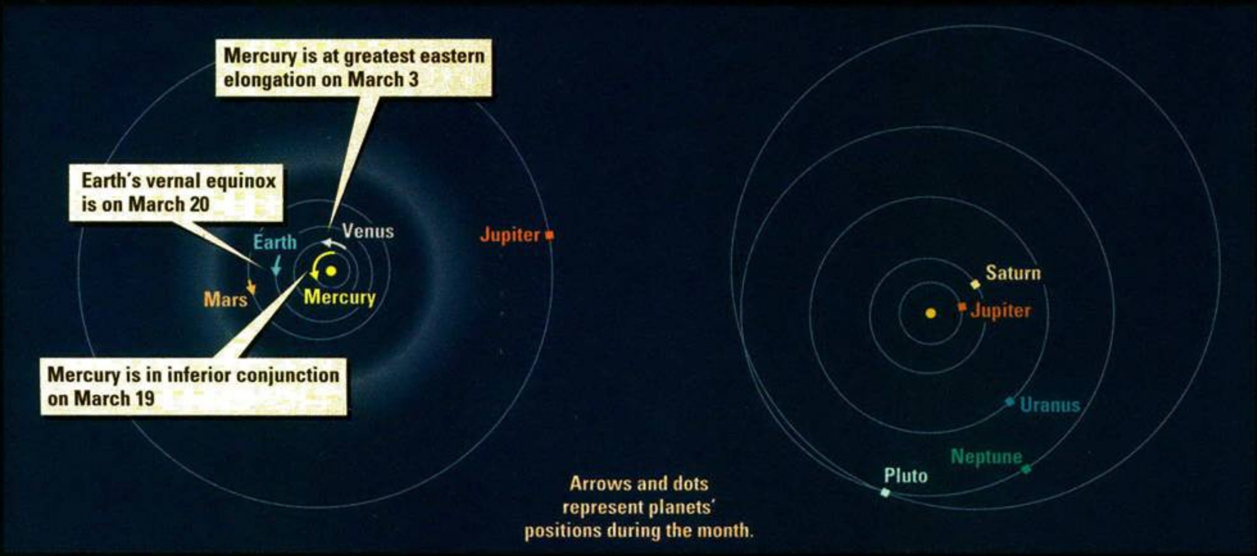
17



JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
March 1	March 15	March 15	March 15	March 15
−2.1	0.5	5.9	8.0	13.8
33.7"	16.6"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
5.844	10.020	20.658	30.756	29.899
4.952	9.251	19.894	30.131	30.141
0h15.1m	2h00.4m	21h10.8m	20h23.5m	16h42.4m
0°26'	9°52'	−16°56'	−19°03'	−10°27'

THE PLANETS IN THEIR ORBITS


Venus
Earth
Jupiter
Mars
Mercury
Saturn
Jupiter
Uranus
Neptune
Pluto

Mercury is at greatest eastern elongation on March 3

Earth's vernal equinox is on March 20

Mercury is in inferior conjunction on March 19

Arrows and dots represent planets' positions during the month.

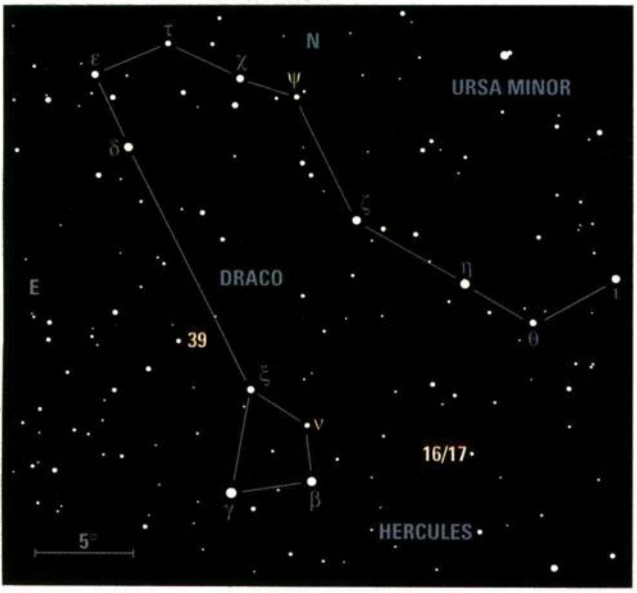
FIRST VIEWS: Doubles in Draco

The sheer size of the celestial Dragon guarantees plenty of interesting objects within it. One of the challenges for beginners is simply tracing the large S-shape of its main stars. The most recognizable place to begin is at the head of Draco. Two of the four stars in the "squashed" box are the only prominent stars low in the north-northeast during spring.

One of the most beautiful double stars for binoculars is Nu (ν) Draconis, the "trampled corner" of Draco's head. It is the faintest of the four that mark the squashed box. The double forms a nearly perfect pair of white 5th-magnitude stars that span a generous 60" of sky.

An easy one-binocular-field slide along the top of the squashed box and to the upper left leads to 39 Draconis. The 5th- and 7th-magnitude stars lie a comfortable 90" apart. For telescope observers, a delightful surprise pops into view — an 8th-magnitude third star just 4" away from the primary star. Look at their hues, what colors do you see?

Another gem, 16/17 Draconis, lies an easy binocular hop from the two bright stars of Draco's head. Shift along the baseline to the upper right and you're there — 90" separate these two as well. Small telescopes easily reveal the 6.4-magnitude third star of this triple system. Admiral Smyth colorfully described it as a "pale lilac" star, 3.4" away from the "pale yellow" one.



All illustrations by *Astronomy*: Elisabeth Rowan

16 and 17 Draconis

39 Draconis

Photos by Tim Puckett

Halfway up to Polaris from the head of Draco lies a trio of modestly bright stars, of which Psi (ψ) Draconis occupies the sharp end of the triangle. Psi has only half the separation that the stars of Nu have, so its 5th- and 6th-magnitude stars will escape all but larger binoculars. They will also be quite a sight in a telescope at low power.

bled, and by July it will be triple this size — evidence that Venus is getting closer to Earth (see "Venus Rising," February 1999, page 80).

As the sky darkens and Mercury and Jupiter set below the western horizon, the stars of winter stand high in the south. Taurus the Bull is beginning its long fall toward the horizon, with the V-shaped Hyades cluster pointing the way.

Just to the north of the Hyades lie two 4th-magnitude stars, Kappa (κ) and Upsilon (υ) Tauri. The minor planet 1 Ceres passes north of Upsilon Tauri on March 14. Its 8th-magnitude makes Ceres an easy, though faint, catch in binoculars. The asteroid betrays itself with its nightly change in position.

As Venus and Saturn set, after 9 P.M. local time in mid-March, look for Cassiopeia, Cepheus, and Ursa Major in the north.

High in the east by nightfall is Cancer the Crab. This faint constellation covers slightly more than 500 square degrees of sky.

The Beehive Cluster (M44, Praesepe) is a fine open cluster of stars and the best known object in Cancer. Galileo's famous tome, *Sidereus Nuncius* (Starry Messenger), holds the first recorded observation of M44 as a star cluster.

North of Gamma (γ) Cancri is the minor planet Vesta. Vesta was at opposition last month and is now wandering slowly toward the west. It fades from magnitude 6.6 to 7.2 during March and is an easy binocular object.

Gemini the Twins passes nearly overhead in the early evening. Its twin stars, Castor and Pollux, enjoy all the attention. Castor is a fine double star visible in many small telescopes. The two components shine at magnitude 1.9 and 2.9. Their combined light makes Castor a magnitude 1.5 naked-eye star.

South of Gemini is Canis Minor, the Small Dog, with its brilliant star Procyon. Like nearby Sirius, Procyon has a white dwarf companion star. The two components are separated by 5.2" and have magnitudes of 0.4 and 10.3.

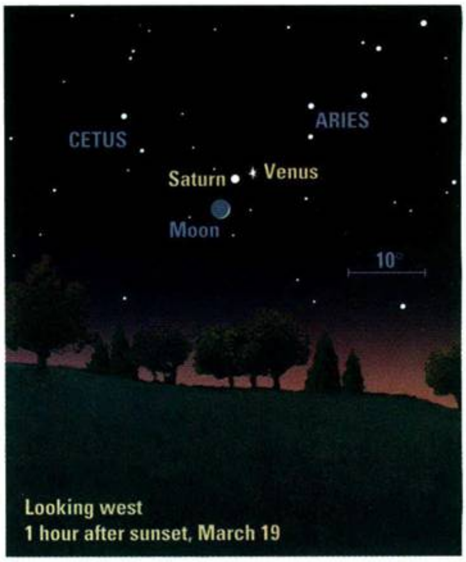
Canis Minor and Canis Major trail behind Orion. The Hunter dominates the winter night sky with his bright shoulder, knee, and belt stars. To the west of Orion is the rather dim area of fall constellations. This year, the otherwise dull area

Venus Meets Saturn

If the clouds blocked views of February's Venus/Jupiter meeting, March offers a fine consolation prize. Venus climbs toward sinking Saturn with a meeting on March 20. A thin crescent moon also joins the pair — see "Colorful Crescent," page 77.

The most remarkable character of this conjunction is its speed. On March 8, Saturn is 12° (two binocular fields) above blazing Venus. It then moves to 10° below Venus a mere 20 days later.

The pair has a modestly close pass (3° on March 18 and 19). The photogenic crescent moon adds a scenic touch on March 19 and 20 — another wonderful opportunity to reel off a couple rolls of film (see "Venus Joins Jupiter," February 1999, page 76).



Looking west
1 hour after sunset, March 19

The Sun's Skin in Spots

Is it a skin condition? No, it's sunspot maximum. Every 11 years, the sun reaches its production peak of intricate and fascinating dark spots and blotches. In complete contrast, a sun at minimum is quite boring in visible light — a cue ball with nary a speck on it.

The first rule when observing the sun is never look at it without proper eye protection. Once a safe solar filter is in place, you're on your way to watching the surface change daily. The sun typically has several groups of sunspots during maximum, and each of these groups may hold 10 or more spots.

The natural tendency is to wait for spots to rotate into view, but spots are always changing and patience will bring rewards. Sunspots evolve from tiny black dots to elliptical shapes with black centers (the umbra), and dappled outer areas (the penumbra). As sunspots grow, their shapes change due to the sun's changing magnetic field.

It's fun to look for familiar shapes among the solar blotches. "Galaxies," especially interacting ones, are often seen through my eyepiece. There are ellipticals and spirals as well.

Those who enjoy observing the sun should seek out the Solar Sections of the Association of Lunar and Planetary Observers (http://www.lpl.arizona.edu/~rhill/alpo) as well as the British Astronomical Association (http://www.ast.cam.ac.uk/~baa).

George Martinez

is punctuated by Venus, Jupiter, and Saturn.

The three bright planets are precursors to the eight brightest winter stars — Aldebaran, Betelgeuse, Rigel, Sirius, Procyon, Castor, Pollux, and Capella. All eleven objects make this late winter sky more interesting. Use the skymaps (pages 69-72) to identify each object.

Reserve the evening of March 19 to take a closer look at Venus and Saturn. On that date, Venus will be less than 3° north of Saturn. A 2-day-old crescent moon also joins the pair. The bright trio shines at magnitude –4.0 for Venus, magnitude 0.5 for Saturn, and a brilliant –10 for the waxing crescent moon. The contrasts will be quite spectacular.

One day later, on March 20, the moon is past the two planets and Venus lies 3° north of Saturn. The ringed planet is a gorgeous sight through a telescope. It's the only object that can surpass the March 19 evening trio. The southern face of the ring system is one of the true wonders of the night sky, and it currently faces Earth. This is the last month that Saturn is visible in a dark sky, so make the most of it. By April, Saturn succumbs to the sun's glow and passes into the morning sky.

Attentions turn toward **Mars** this month as the season for observing the Red Planet gets underway. For a couple of months before and after its April 24 opposition, Mars presents its most favorable aspect to Earth. From now until mid-July, Mars's disk will be over 10" in diameter. This allows small telescopes to see appreciable surface detail.

Mars rises shortly after 11 P.M. local time on March 1 and two hours earlier by

Mars in Motion

At long last, Mars rises before midnight giving early birds a decent view. On March 1, Mars shines at magnitude –0.2 and spans more than 10". The planet's surface features will be easy to see. The longer you stare at it, the more you will notice.

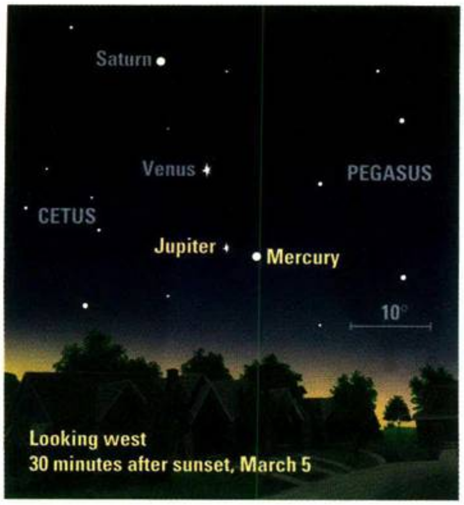
Because Mars is only one orbit farther from the sun than Earth, it moves rapidly through our sky. On this celestial racetrack, we've nearly caught up to Mars. Earth overtakes it next month when the Red Planet is at opposition, or opposite the sun in our sky, on April 24. Through March, Earth races to catch Mars in this orbital competition. The motion makes Mars appear to slow its course with respect to the stars.

Mark Haslam

Once you've seen Mars, take a close look at Antares rising two hours later. Its name, Ant-Ares, translates as "rival of Mars," because the star nearly matches the planet in color. Early March finds Mars a full magnitude brighter than the distant star, and it will gain another magnitude by April. While you're out, also compare Mars to Arcturus, another orangy star.

The Messenger Meets the King

Every day this month there is something interesting to see during evening twilight. With the exception of Mars, the summer planet show will be rather sparse, so get out there now, before it's gone.



Looking west
30 minutes after sunset, March 5

Say good-bye to Jupiter as Earth passes it on the inside orbital track. This month, Jupiter appears to fall toward the sun. The rapidly lengthening days of spring add to this effect.

Watch carefully, as Mercury climbs rapidly to meet Jupiter above the horizon. Though it can't match Jove's brilliance, Mercury's speedy ascent is no match for lumbering Jupiter.

On March 1, magnitude –0.5 Mercury stands 5° to Jupiter's lower right (west). One week later, Mercury is 4° due right of Jupiter. With Mercury leading the way, the twosome then appears to sink together into the twilight glow.

Ambitious observers will not only see Mercury's speed with respect to Jupiter, but will also discover the speed at which the planet's phase changes. On March 1, Mercury's tiny 7" disk displays a half-moon shape 54 percent lit. Only one week later, it's a mere 23 percent illuminated 9" disk — a classic thin crescent.

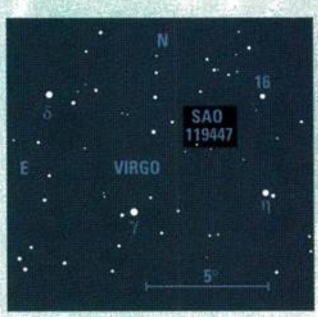
Observer's Challenge: Quasar-Galaxy Link Controversy

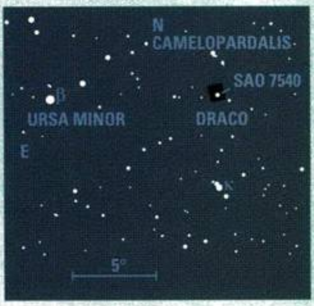
Because challenging objects are often at the forefront of astrophysical inquiry, they are fun objects to hunt. Quasar 3C 273 is a classic example. It's a 13th-magnitude speck of light in the eyepiece, yet it holds deep significance to observers. The fact that it's a quasar some 2 billion light-years away makes it a thrill to view.

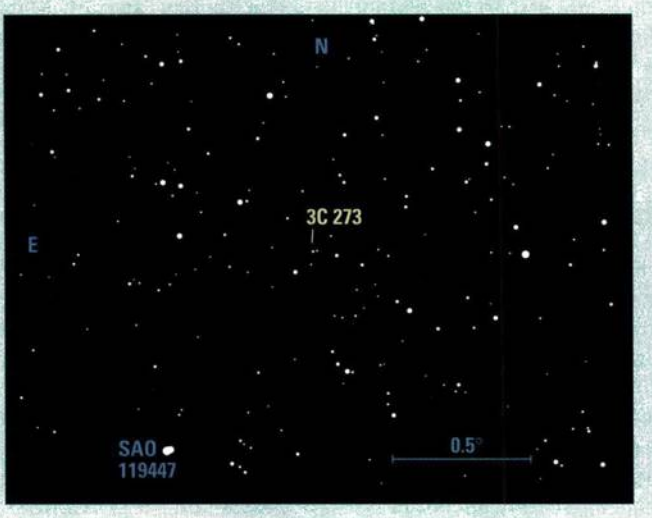
Another quasar is Markarian 205 in Draco. It is one of the easiest quasars to see in a 10-inch telescope. After more than a decade, some controversy still surrounds this object's measured redshift. A small number of astronomers believe that a bridge of matter connects the quasar to the bright galaxy NGC 4319. This implies that the two are together and not separated by the vast distances that their redshifts indicate.

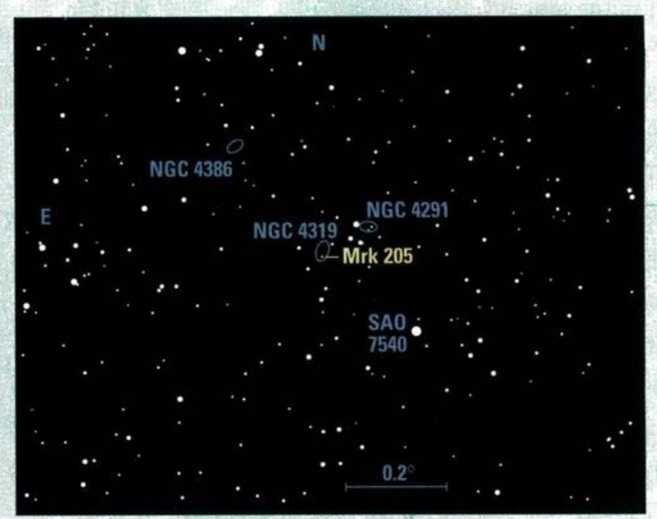
The galaxy and quasar lie roughly halfway between the bowl of the Big Dipper and Polaris. Because of their proximity to the pole, it's best to dial in the coordinates: 12h21.7m 75°19' (2000.0).

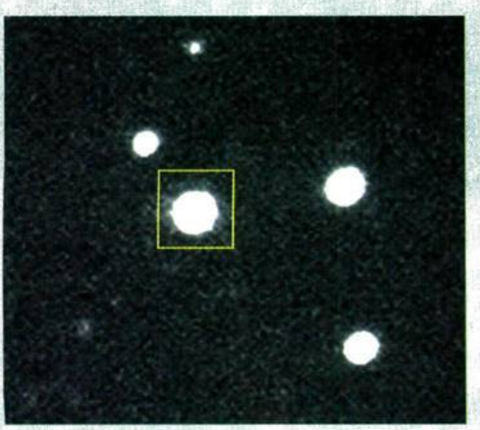
Dobsonian users have a relatively easy star hop to Markarian 205. Start between Kappa (κ) and Lambda (λ) Draconis, the tail stars of the dragon. Then head north 5° (about 1 field of view in an 8x50 finderscope) to a 5.5-magnitude star. In the low-power field of this star, you'll see two 12.2-magnitude galaxies to the northeast (in the evening sky, this translates to down toward the horizon). The object closest to the star is NGC 4291, an elliptical galaxy. The much larger object is NGC 4319. Increase the magnification past 150x. Look at the edge of the fuzzy halo that points back to the 5.5-magnitude star. There you should see another faint "star," Markarian 205. It's insignificant to the eye, yet so important to our quest for knowledge.



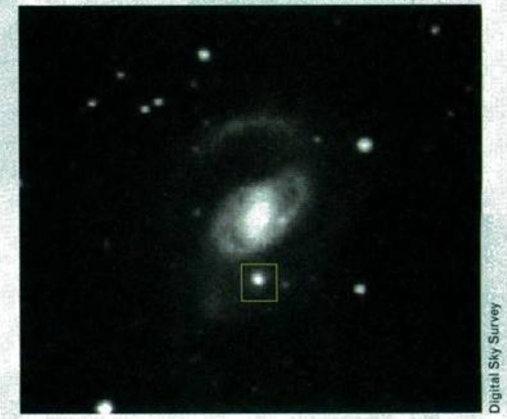








Jack Newton



Digital Sky Survey

March 31. It competes with the glow of Arcturus to the north and reaches its highest point above the southern horizon a couple of hours before dawn. In the third week of March, its easterly motion slows against the background stars. Mars then begins its retrograde loop. Retrograde motion is similar to watching another car as you pass it. The slower car appears to move backward relative to your car. In the context of the solar system, Earth is beginning to overtake Mars. Eventually the red planet will swing back toward Spica in Virgo.

Shining at a stunning magnitude –1.0 by March 31, Mars is visible for the rest of the night among the stars of Libra. Its apparent diameter has now grown to 13". By April 24, it will increase in apparent size by another 3".

The trick to observing Mars through any size telescope is to catch the brief moments of seeing through our unsteady atmosphere. These moments usually last only seconds, but observers patiently wait for them to see the finest detail on the Red Planet.

The spring Equinox occurs at 8:46 P.M. EST on March 20. On this day, observers at the north and south poles can theoretically see the sun traverse the entire horizon during a 24-hour period. It also marks the beginning of spring in the Northern Hemisphere, and the beginning of autumn in the Southern Hemisphere. **A**

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

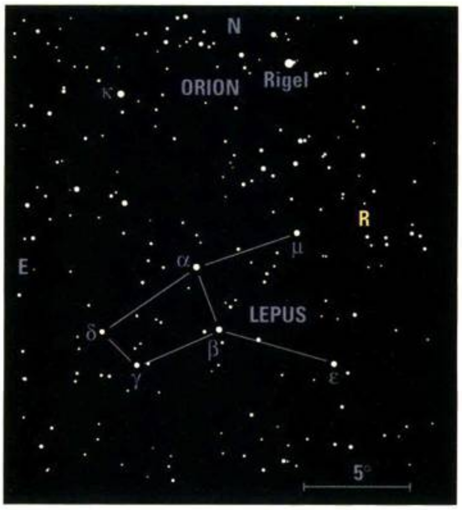
Hind's Crimson Star: R Leporis

Variable stars deserve to be viewed more widely by backyard observers. They change brightness, have color, and are often easy to see in the light-polluted city.

R Leporis is fairly easy to find. It sits on a line from Betelgeuse through Rigel, and on another line that extends from the top center star through the top right star of Lepus's squashed box outline.

Although R Leporis can fall below 11th magnitude, it should be near maximum in March — perhaps appearing to be a 6th-magnitude drop of blood. If Mars is red, then it's anemic compared to R Lep. Those wishing to monitor its brightness should do so every three weeks. R Leporis is a Mira-type variable; it takes more than a year to complete one cycle. Does its color change as well?

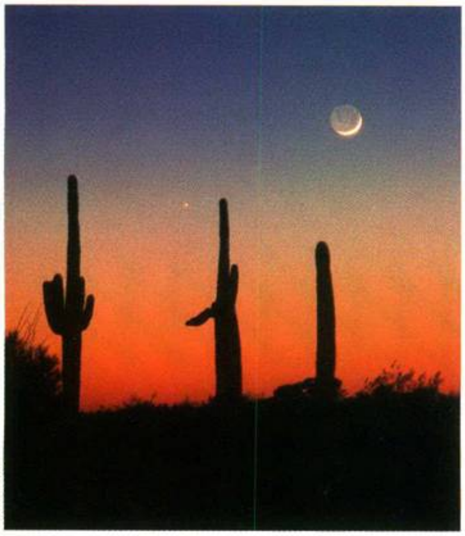
If you have a spectroscopic eyepiece or even a cheap diffraction grating from the local science shop, look at the star's spectrum. When compared to a star like Rigel, R Leporis has an extended red end.



The most striking difference is the large number of dark absorption lines. For amateurs, this sight is interesting. To the professionals, those dark lines help them to determine composition and a whole host of other characteristics.

Colorful Crescent Out of the Cradle

For the average suburbanite, young crescent moons are too often a considerable challenge to observe. There are trees and a rapidly ticking clock that counts down to moon set. However, this month offers a decidedly easier 30-hour old crescent.


Frank Zullo

On March 18, forty minutes after sunset, a gorgeous sliver stands with its horns to the east a comfortable 5° above the horizon — half the width of your fist held at arm's length. For observers near 40° north latitude, Venus and Saturn will look like a pair of eyes peering down at the crescent.

The important factor in seeing a young moon is the season. In spring, the ecliptic stands nearly perpendicular to the horizon in the evening sky. During the autumn months, this line forms a shallow angle with the horizon. Even if the moon or planets have large elongations from the sun, in autumn that distance will not translate into height above the horizon.

Watch for the especially beautiful ashen light — the old moon in the new moon's arms. At that time of day, the sunlit hemisphere of Earth lies just to your west. This sunlight is reflected out toward the moon where it lights the dark portion of the moon's face: Hence its popular name, earthshine.

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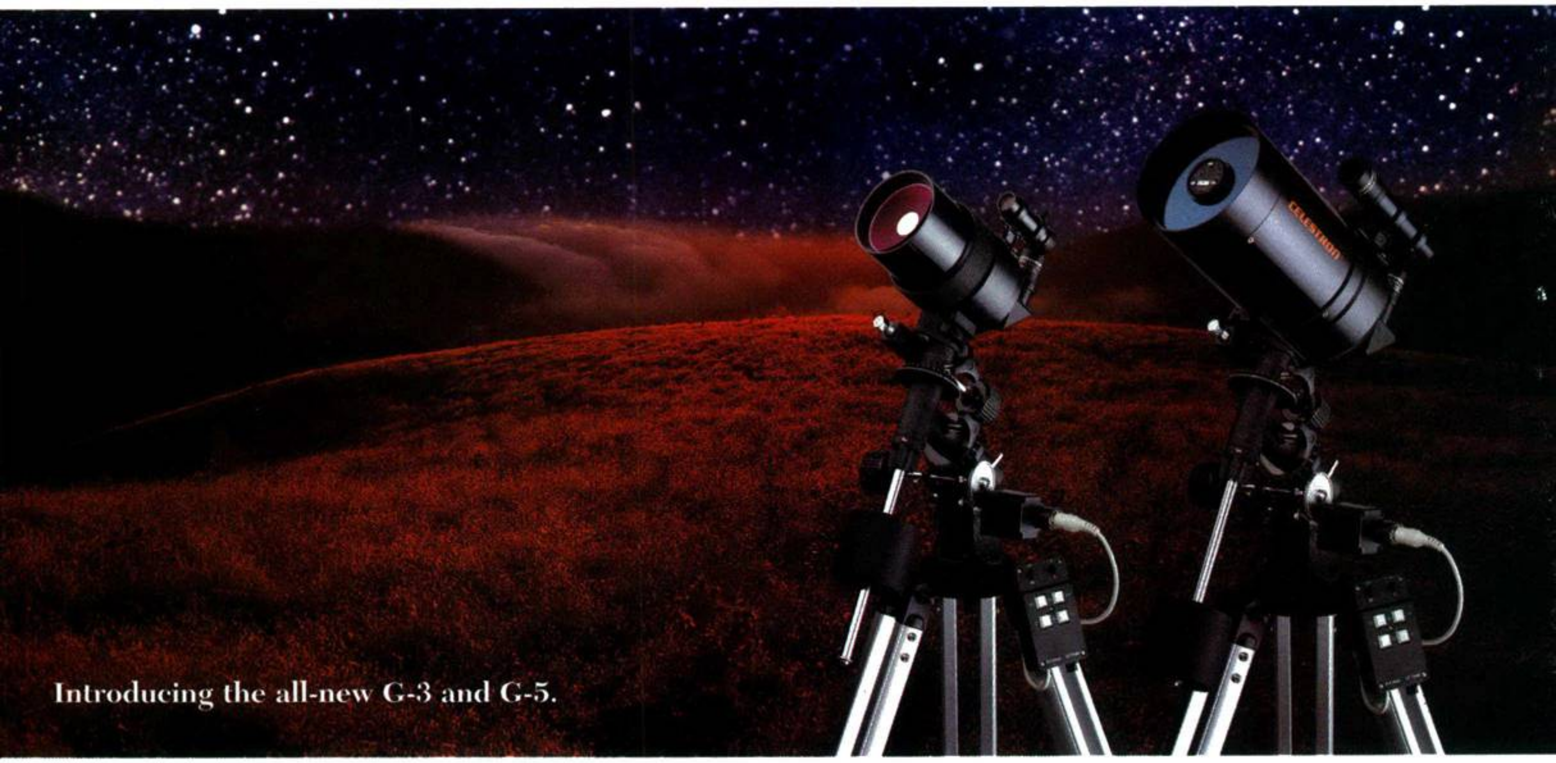

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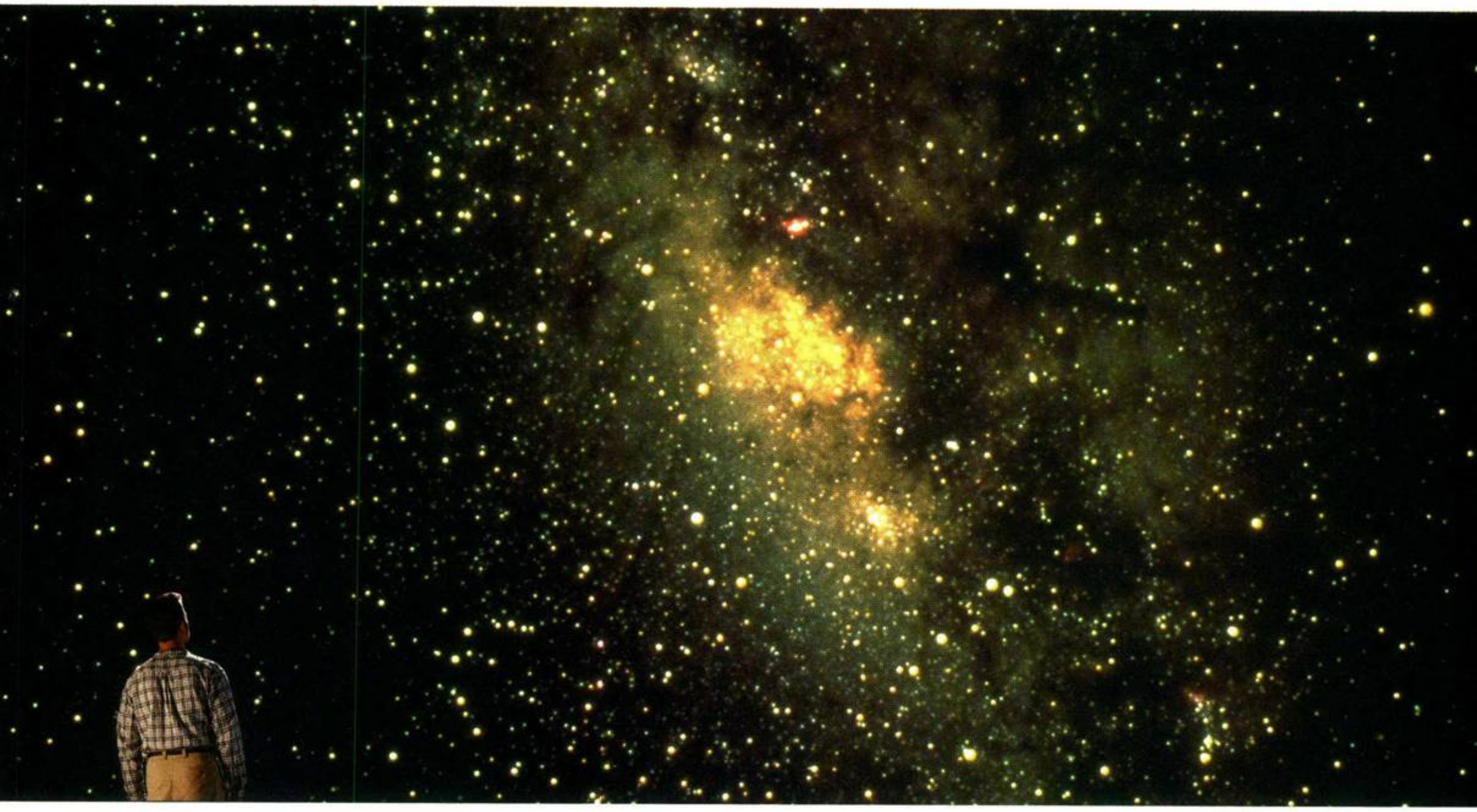
The Universe.



Milky Way photo courtesy of NOAO.

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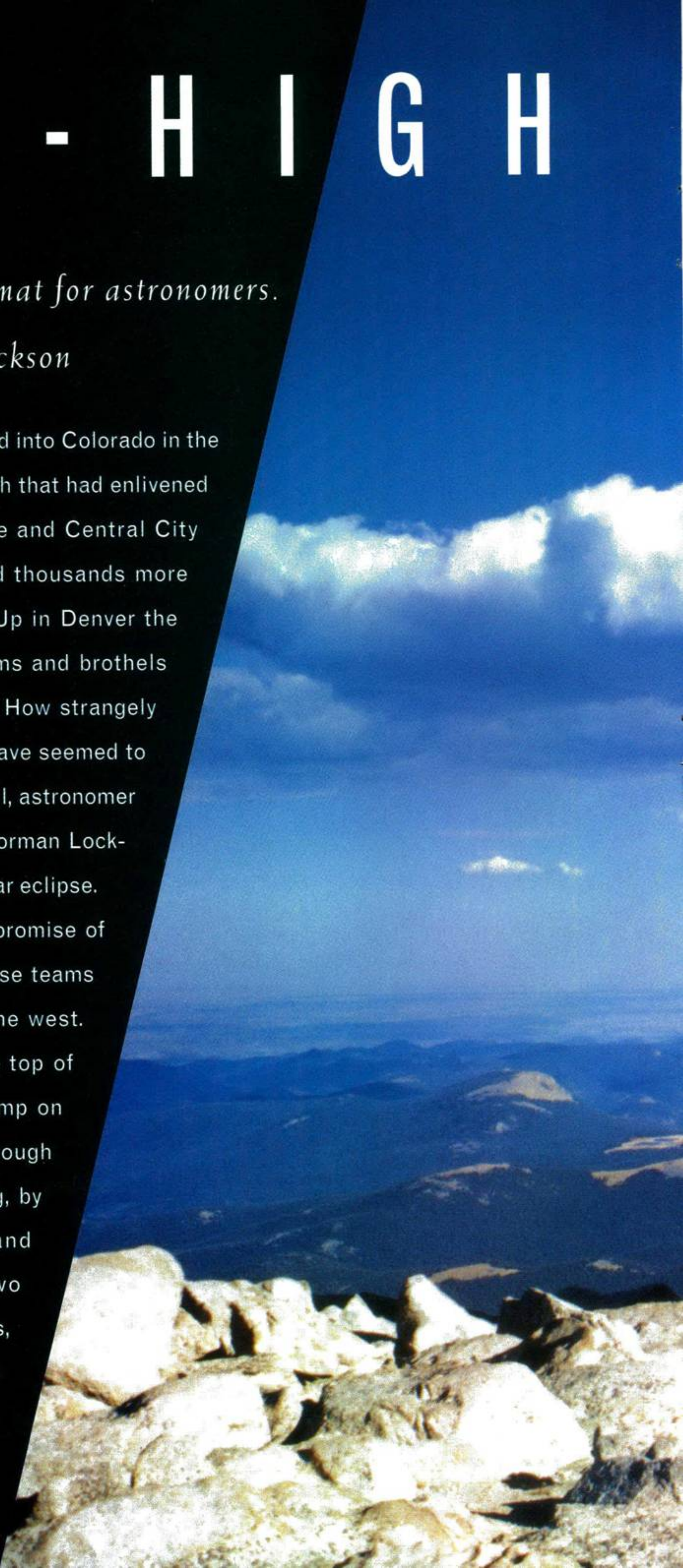
MILE-HIGH

Colorado puts out the welcome mat for astronomers.

By Nancy Hendrickson

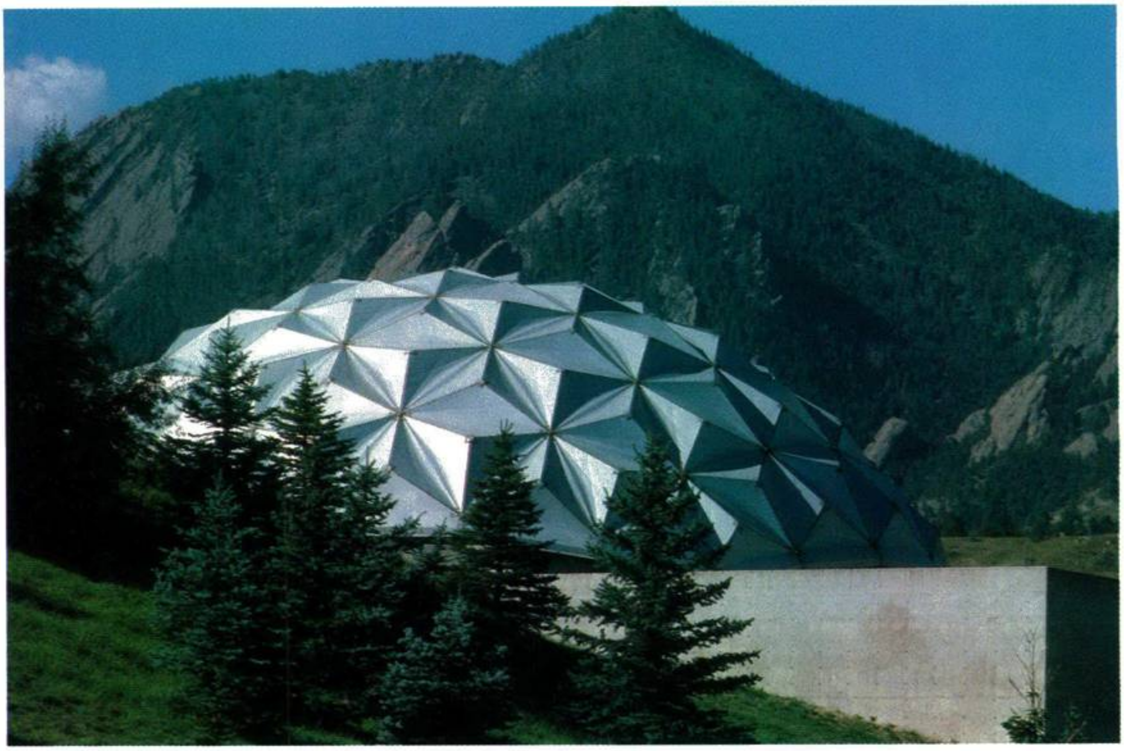
The world's most noted astronomers poured into Colorado in the summer of 1878 at the height of a silver rush that had enlivened the region's boomtown society. Leadville and Central City exploded with overnight millionaires and thousands more who could only dream of the big strike. Up in Denver the newly rich reeked of wealth, and barrooms and brothels were eager to snap up the spare change. How strangely exciting these muckers and miners must have seemed to the likes of comet discoverer Maria Mitchell, astronomer Samuel Langley, and solar physicist Sir Norman Lockyer — all in Colorado to witness a total solar eclipse.

Drawn by clear, clean skies — and a promise of half-price fares from the railroad — eclipse teams from most of the major universities came west. Some, like Langley, went straight to the top of Pike's Peak, while others made their camp on Cherry Creek, just south of Denver. Although the morning's weather looked threatening, by eclipse time the skies had cleared and astronomy's best were treated to two minutes and 40 seconds of totality. It was, as one of the group said, a "token of the inviolability of law."



University of Denver/Peter Gannis

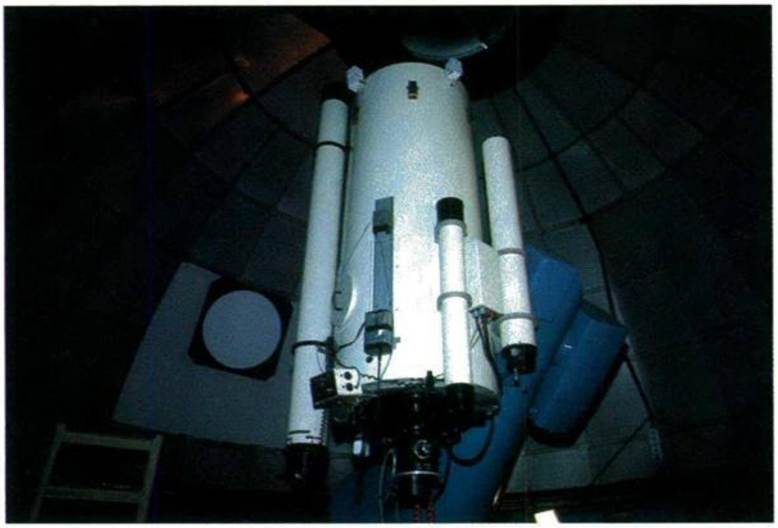
ASTRONOMY



Fiske Planetarium at the University of Colorado in Boulder, right, welcomes visitors but beckons school kids. Nearby, the Sommers-Bausch Observatory holds a 24-inch telescope, below. Previous page: Meyer-Womble Observatory, at 14,000 feet, is the world's highest.

RIGHT: University of Colorado/Ed Kosmicki

BELOW: Nancy Hendrickson



Of course, that July 29 eclipse wasn't the beginning or the end of Colorado astronomy. In 1880, a promising young astronomer named Herbert Howe made a surprising career move by leaving astronomy's Eastern inner circle and moving to Colorado, hired as a math and astronomy teacher.

Howe's reputation caught the attention of Humphrey Chamberlin, a Civil War telegrapher made rich on Denver real estate. Interested in astronomy himself, Chamberlin contacted Howe and offered to finance a telescope for the University of Denver. Chamberlin Observatory was in operation by 1894 and the jewel in its crown was a 20-inch Alvan Clark refractor. The red stone observatory was built in the Richardson Romanesque style and is characterized by massive archways and heavy, rough-cut stone walls.

On Chamberlin's first public night, members of the Swedish Methodist Christian Endeavor Society were treated to views of Saturn and its rings (one disbelieving member thought the ring system had been painted on the glass). More than a half-million people have used the scope since.

Located in a neighborhood of Victorian homes, Rocky Mountain phlox, and blue spruce, Chamberlin still opens its doors to visitors. Members of the Denver Astronomical Society hold public nights at Chamberlin, featuring a slide show and a peek through the 20-inch telescope.

Gates Planetarium

Far more modern than Chamberlin, but just as treasured, is the Gates Planetarium at the Museum of Natural History. Classes in astronomy, astronomical history, and family astronomy are conducted at Gates, as are public planetarium shows. "Colorado Skies" takes viewers month-by-month through the constellations, planets, and celestial events here in the Centennial State, while "To Worlds Beyond" features a Patrick Stewart-narrated voyage through the solar system. Gates even offers "Skies for Scouts" — a program for Boy and Girl Scouts earning badges in space science and astronomy.

While Denver has Chamberlin and Gates, a half-hour drive north will take you to the vast sky resources in Boulder. This is a university town, and anything goes. On a walk down Pearl Street Mall, you're just as likely to bump into a violin-flute duo as a fire-eating street performer with eggplant-colored hair.

From Pearl Street, drive down Broadway to the University of Colorado campus, home of Fiske Planetarium and Sommers-Bausch Observatory.

Catharine Garmany, a professor in the Department of Astrophysical and Planetary Sciences, heads up both facilities.

A scale model of the solar system stands just outside the Fiske, the building with the shiny silver dome and Mayan-looking walls. Although I know full well how enormous astronomical distances are, I was amazed when I walked the model. The sun, Mercury, Venus, Earth, and Mars are just a few feet from one another, but I had to cross the street (the asteroid belt), and take off across campus to catch up with the rest of the planets.

Cosmic Collisions

Fiske is a favorite field trip destination for schoolkids who are treated to shows on the solar system, Mars, rockets, and spaceflight. Friday evening shows for the public include productions on black holes, historical skies, and distant worlds. I watched a show called "Cosmic Collisions," which had been produced on site and was scripted by Garmany and Geoff Skelton, the planetarium's program supervisor. It was created when Comet Shoemaker-Levy 9 collided with Jupiter.

Producing a planetarium show takes from six months to a year. Here at Fiske it's done on a small budget, using an on-site audio studio, 200 slide projectors, a dedicated staff, and a 14-foot tall Zeiss Mark VI star projector, fondly known as Fritz. While Fritz projects stars onto the dome, the rest of the program and special effects are controlled by the slide projectors and Geoff's magic. Want a chaotic universe? Use a kitchen colander and flashing lights. Globs of glue and glass create swirling ripples, while overlapping streamers of flowing light are conjured using a light bulb and a diffraction grating mounted on a rotating disk.

On selected Friday nights, following the planetarium show, everyone heads up the hill to the Sommers-Bausch Observatory (SBO) for an open house and public observing. There, 16-inch and 18-inch Cassegrains on the observing deck are used along with tripod-mounted binoculars.

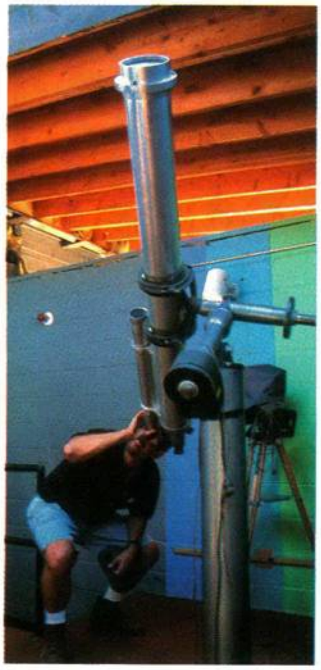
SBO's original telescope, donated by the Bausch and Lomb Company, was a 1912 vintage, 10.5-inch refractor. The observatory was built in 1953 and was owned jointly by the university and the High Altitude Observatory. Back when radios were bigger than cars, the room under the dome served as a communications center connecting the

THOSE LUCKY KIDS!

Each year, thousands of kids who live in the Denver School District get the chance to experience astronomy in the interactive environment of their own planetarium. Built during the 1960s Space Race, the project reflected the "can do" spirit of the era. With 80 percent of the funding from the National Science Foundation, the planetarium was an immediate success, and more than 40,000 visitors came during its first year.

The planetarium, upgraded in 1995, is under the direction of Jim Beaber, a former Earth sciences teacher. A 125-seat facility with a 10.1 meter dome, it is used by students from grades three through six. Each year, the program builds on students' experience from the year before. While each show is scripted, Beaber and his assistant may veer off into related topics, directed by student interest.

The program for third graders begins with a discussion of all the things in the sky — from birds and clouds to planets and the Milky Way. They may be asked to count all the stars in the sky ("No way!" they respond), or at least to estimate how many they can see.



Jim Beaber uses a small observatory to help kids grasp astronomy.

Nancy Hendrickson

By the time the kids hit the sixth grade, they're in for an experience I wish I'd had. For a week, they stay at an Outdoor Laboratory School at either Mt. Evans, where they use Meyer-Womble Observatory, or Windy Peak. At Lab School, several daytime activities and one full night are devoted to astronomy. Everyone gets to observe through the several telescopes at the sites. Students make sundials and observe the sun with solar-filtered telescopes and an H-alpha filter. Heliostats are used not only to view the sun but to create solar spectrums.

After the week at Lab School, the students return to the planetarium to talk about concepts like stellar evolution and the formation of the universe. Its popularity is clear — in an exit survey of graduates, the Lab School always ranks number one and the planetarium a close second as favorite learning experiences.

In the near future, Beaber hopes to open the planetarium to the public with interactive programs. As he says, "Teaching science isn't about facts, it's about getting kids excited."-NH solar observing facilities at Climax, Colorado, and Sacramento Peak, New Mexico.

Today, a 24-inch telescope built by Boller & Chivens takes the place of the old refractor and is used primarily for CCD imaging by graduate students. The old refractor sits in the Fiske lobby, its primary lens put to good use in the university's heliostat, a kind of solar telescope that relies on projection. Reminiscent of Chamberlin Observatory's first light, the Fiske folks have placed a fake Saturn inside the old refractor, giving visitors a moment of pause.

When I visited, 60 people, from pre-teen to post-retirement age, stayed for the observing run. First, the computers slewed the scopes to some of the finest double stars — Cor Caroli, Albireo, and Epsilon Lyrae (the Double-Double). As the night grew darker, the scopes turned to nebulae. When the Ring Nebula came into view, a young boy tried, unsuccessfully, to teach his grandmother to view it using averted vision. Disappointed, he described it to her as a "cool, gray smoke ring." Of the objects viewed that evening, the crowd-pleaser was Albireo, with its brilliant blue-gold pair.

In addition to the public programs at Fiske and SBO, the astronomy department is actively involved in an outreach program that includes sending astronomers into classrooms and presenting workshops for teachers.

A close eye is kept on the sun by another Boulder-based institution — the National Center for Atmospheric Research (NCAR). Although the first recorded experiment on the atmosphere was conducted as early as 450 B.C. (a keg with holes in each end was plunged underwater to show that "empty" space was full of air), it wasn't until World War II that atmospheric research hit its stride. Then weather predictions became critical in battle planning and tracking the solar emissions that disrupted Allied radio communications.

Tornadoes and the Sun

The scientists here at NCAR study processes that drive weather and climate, from ocean depths to the solar core. The lobby level exhibits illustrate NCAR's research on storms and weather, including tornadoes and microbursts — the most dangerous form of windshear. Boulder, itself, is perfectly situated to study downslope winds. Located on the eastern foothills of the Rocky Mountains, winds up to 100 miles an hour sweep down from the mountains, causing about $1 million of damage each year.

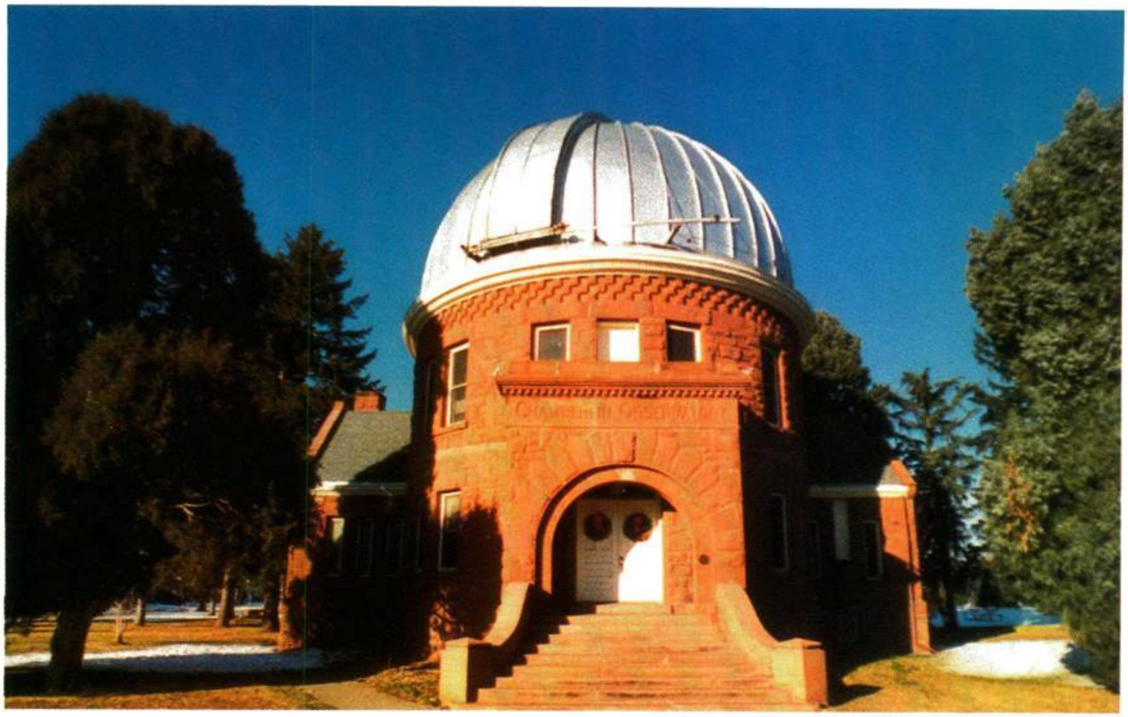
On the second floor, exhibits illustrate the relationship between the sun's activity and Earth's climate. The Newkirk White Light Coronal Camera is at the top of the steps and is used by scientists from the High Altitude Observatory to obtain data from solar eclipses. Since solar radiation is the main source of atmospheric energy, the sun is a major focus of weather research. Looking at the coronal camera, I wondered how Maria Mitchell would have put it to use during her eclipse trip.

When Mitchell and the others arrived in that

DENVER MUSEUM OF NATURAL HISTORY

The Gates Planetarium in Denver's Museum of Natural History offers classes and a variety of public shows.

Gates Planetarium/Annette Slade



The Denver Astronomical society holds public star gazing nights at the Chamberlin Observatory in Denver, built in 1894. Dan Wray

summer of 1878, they couldn't have expected much. Colorado's statehood was barely two years old. Gunslinger Doc Holliday was still ten years away from his end down in Glenwood Springs, and Herbert Howe's observatory wasn't a flicker in his consciousness. However, they did get two minutes and 40 seconds of totality. When I arrived, 120 summers later, I didn't observe an eclipse, slew a Clark, or tangle with a miner. But I did get to see planetariums that educate as well as entertain and public observing programs that enlighten and inspire. But best of all, I witnessed an inventiveness the old-timers would have applauded. Looking for fine public astronomy? Come on up.

Observing

To escape the Denver light dome and reach clear skies, you must drive about an hour and a half into the mountains, says *Astronomy* contributing editor Patti Kurtz, who lives in Denver. She wouldn't reveal her favorite spots, except to say they are southwest of the city. "Remember, to get absolutely great skies, you have to put a whole mountain range between yourself and the Denver lights," she says. In the winter, when the roads to great mountain observing sites are covered in snow and ice, Kurtz suggests going east into the Colorado plains. "But you have to go a long way."

If you are in Colorado and would like to meet some native astronomers, try to hit a star party or two. This is very active observing country, and large star parties are organized from May through October by regional observing organizations. The Denver Astronomical Society (DAS), for example, hosts a monthly star party near first quarter moon and, according to DAS secretary, Patrick Ryan, "When a comet's in the sky, the turnout can soar to more than a thousand." The society also regularly hosts open houses at the Meyer-Womble Observatory on Mt. Evans. At 14,000 feet, Meyer-Womble is the highest observatory in the world.

Other Colorado organizations include the Colorado Springs Astronomical Society, the Longmont Astronomical Society, the Northern Colorado Astronomical Society, the Boulder Astronomy Club, and the Western Colorado Astronomy Club, which — with the Denver group — compose a regional group called the Front Range Astronomical Super Cluster. ◼

Nancy Hendrickson is a freelancer who loves traveling to discover astronomy's most entrancing destinations. She co-authored, along with David Cortner, Eight Easy Observing Projects for Amateur Astronomers. *Reach her by e-mail at stjoemo@ibm.net.*

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Reborn Classic

Celestron's timeless C-8 gets a face-lift.

Text by Phil Harrington and photos by Bill Zuback

The world of the backyard astronomer was a different place before 1970. Most dedicated observers owned a 6- or 8-inch Newtonian reflector on a massive German equatorial mount. Although these instruments worked well, they were cumbersome, and many sat unused.

In June 1970, a relatively unknown company named Celestron Pacific introduced a new kind of instrument to the hobby marketplace: a Schmidt-Cassegrain Telescope (SCT) called the Celestron 8. The Celestron 8 had everything an urban or suburban astronomer could want: a reasonably large aperture, an equatorial mount, and — most important — a compact, convenient design. C-8s were an instant success.

Today Celestron continues to produce its venerable 8-inch SCT. Models range from the basic instrument with minimal frills to complex, computer-controlled super telescopes. I put the most basic version, the Celestar 8, through its paces for this review.

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The Drop Test

The Celestar 8 was shipped directly from the manufacturer, in Torrance, California. Nobody was home when the the nationally recognized delivery service (no names please) literally dropped it off. In an effort to leave the telescope hidden from the view of a potential thief, the deliverer decided to toss the packages over the six-foot-high stockade fence that separates the front from the backyard. Not only were the packages heavy, but Celestron had dutifully labeled each "fragile." To say I was shocked is an understatement. Quickly unpacking the boxes, I found that none of the components suffered any apparent damage from their harsh treatment. Even the instrument's optical collimation remained true, a testament to Celestron's packaging.

Initial Setup

Celestar's optical tube assembly comes attached to the fork equatorial mount. One need only attach the 6x30 finderscope and insert the 90° star diagonal (both included). The Celestron Wedgpod also comes fully assembled. Just take the unit out of its box and spread the tripod legs.

Three common 8-inch hex-head bolts attach the telescope to the mounting plate of the "wedgpod" — the clumsiest part of the setup. Although they work fine, hex bolts cannot be tightened by hand. To remedy this, purchase three thumbscrews from a hardware store. They will make life much easier.

Fit and Finish

Despite the rough delivery, the telescope's finish survived unscratched. Like all modern Celestron Schmidt-Cassegrains, the Celestar 8's aluminum tube sports a high-gloss, black finish. The quality of the paint job is flawless, with no evidence of overspray or "orange peel" texture. The fork arms and base, as well as the wedgpod, all feature a black "crinkle" finish, while the ends of the two-inch-diameter tripod legs are each covered with a black, rubber cap.

The wedgpod's motions in both right ascension and declination were very smooth, with no evidence of binding. Both axes come with thumb locks and manual slow-motion controls. Once the telescope is aimed at a particular object and the thumb locks secured, the user can adjust the instrument's aim either by twisting the two slow-motion knobs or by using the clock drive's hand-held controller (an optional motor is required for the declination axis).

Under the Stars

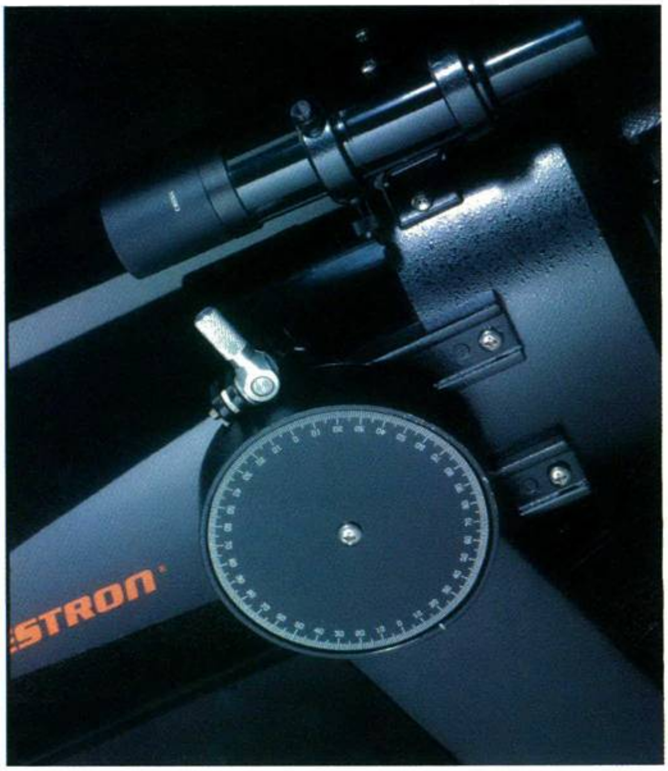
The Celestar was put through its paces under a wide variety of sky conditions. It held up well, with stars focusing to sharp points, even at high magnifications. The views of some favorite deep-sky objects (the Orion Nebula, Hercules Cluster, Whirlpool Galaxy, M81, and M82) were all very nice, as were the views of the planets Jupiter and Saturn. The telescope also handily passed the more telling star test.

As the name implies, the star test simply uses a star and a moderately high-power eyepiece (roughly 25x per inch of aperture on a steady night) to check the quality of a telescope's optics. For the Celestar 8, a 10.5mm Plössl eyepiece (190x) was used on a 4th-magnitude star. The target star was centered in the field of view, focused precisely, and examined. At high magnification, a star looks like a bull's eye. It appears to have a bright central disk (the Airy disk) surrounded by one or two faint concentric rings (diffraction rings). By definition, any telescope that claims to have "diffraction-limited" optics must show this pattern.

Once the Celestar cooled to the ambient air temperature, the bull's eye was exactly what I saw. Further, by slowly racking the image slightly out of focus — first in one direction, then the other — the image expanded to a nearly textbook pattern of concentric, alternating dark and light rings. More important, the images were nearly identical on either side of focus. This indicates first-rate optics.

The star test is fine for examining optical quality, but how well would the Celestar perform against some real competition? For a side-by-side comparison, the f/10 Celestar was pitted against my vintage Criterion Dynascope RV-8, an 8-inch f/7 Newtonian reflector. The RV-8 was one of the best-selling telescopes when the original Celestron 8 was introduced. It has exquisite optics that produce perfect star images. How would the C-8 stand up to such stiff competition?

It held up very well. By operating both telescopes at effectively the same magnification, the views were strikingly



similar. Views of galaxies and open star clusters appeared virtually identical through both. However, planetary and emission nebulae detail, and stellar resolution in globular clusters were slightly more apparent through the Newtonian.

Why these differences in telescopes with the same aperture? Image contrast. The large secondary mirror in a Schmidt-Cassegrain creates a relatively large central obstruction. When something is placed in the optical path of a telescope, it blocks a portion of the incoming light. The larger the obstruction, the greater the loss of contrast.

The Celestar's central obstruction measures 2.7 inches (34 percent by diameter or 11 percent by area), while my 8-inch Newtonian's diagonal mirror produces a 1.5-inch central obstruction (19 percent by diameter or 4 percent by area). When Schmidt-Cassegrains are compared with refractors and higher focal-ratio Newtonians, SCTs fall short on contrast. It's the price paid for such a compact and portable design.

Precise polar alignment of the Celestar is difficult to achieve. The mount lacks a method for fine tuning its latitude or azimuth. If the telescope is slightly east or west of true north, you must physically pick up the instrument, turn it slightly, and set it back down. Adjusting the latitude angle can also prove cumbersome. While a graduated latitude scale found on the wedgpod will help make the rough setting easier, fine tuning in the field is inevitable. For this, the user must loosen two pairs of screws, tilt the telescope by hand, then tighten the screws. More sophisticated (and costlier) mountings often feature built-in fine adjustments for both latitude and azimuth settings.

Like nearly all equatorial mounts, the Celestar comes outfitted with a pair of setting circles. These circles are accurate enough to point the instrument in the general direction of an object, though some searching will most likely be required. If you want or need a very high degree of positioning accuracy, consider a telescope outfitted with digital setting circles, like the Celestar Computerized.

The C-8 also comes with a clock drive that tracks the stars once the mount is polar aligned. Unlike the AC-powered clock drive used on the original, the Celestar's drive is totally self-contained, powered by a single 9-volt battery — a great convenience. A small hand controller for speeding up or slowing down the telescope's tracking rate is also included.

All clock drives, no matter how well they are made or how precisely they are polar aligned, will not track the sky perfectly. Even the most accurate clock drives, those that use mating worm-gears, will slowly, but regularly, speed up and slow down in a motion called "periodic error." Because periodic error is, well, periodic, an electronic circuit can be built into the drive to correct for these irregularities.

The Celestar uses a "spur-gear" drive, which is also prone to tracking error. However, the irregularities are neither regular nor predictable. This makes compensating and correcting the errors more difficult. I must emphasize that these irregularities are very small. Spur-gear drives are fine for visual observing. Indeed, once polar aligned, the drive kept an object in the eyepiece's field of view for extended periods without having to readjust the aim. The Celestar's drive is also accurate enough for piggyback astrophotography, where the telescope is used as a tracking platform for a camera and lens mounted to the side of the tube. The problem arises with long-exposure, through-the-telescope photography of faint deep-sky objects. Spur-gear drives are not accurate enough for such use. Instead, you need a precision worm-gear drive like the one found on the Celestar Deluxe.

Standard Celestar 8 Specifications

Aperture: 8 inches (203 mm)

Focal Length: 2032 mm

Focal Ratio: 10

Weight: 37 lbs.

Fork Mount and Wedgpod

Standard Accessories: 25mm SMA Eyepiece (81x), Star Diagonal, 6x30 Finderscope

Retail Price: around $1,200 (varies with dealer)

Hand Controller Retail Price: around $75 (varies with dealer)

For more equipment reviews, visit *Astronomy*'s website at http://www.astronomy.com.

Standard Equipment and a Wish List

Along with the fork mount, clock drive, and wedgpod, the Celestar also comes with a 25mm Super Modified Achromat (SMA) eyepiece and 6x30 finderscope. The eyepiece produces a magnification of 81x, fine for a first view. Expect to replace it quickly with a wider variety of better-quality eyepieces. (For further information on eyepieces, see "Getting to the Focal Point," July 1998.)

You might also want to consider upgrading the finderscope. Like the supplied eyepiece, the 6x30 finder is fine to start with, but you will quickly discover that its small aperture makes star hopping difficult. Most experienced observers agree that the smallest useful size for a finderscope is 8x50 which, under suburban skies, will penetrate to roughly 8th magnitude. Celestron and several other manufacturers offer good selections of larger finders from which to choose. Happily, the spacing for mounting finder rings is standardized. Simply unscrew the mounting bracket of the 6x30 finder and replace it with the new bracket.

Another add-on may include the Celestar dew cap to prevent the corrector plate from fogging up — a common problem in more humid climates.

The Bottom Line

The Celestar 8 is a competent performer that will give observers years of enjoyment under the stars. The optics in this test scope were very good, as were the mechanical components. The instrument was delivered ready to operate right out of the box, a plus compared with some telescopes that require a fair amount of assembly before they can be used. The convenient size of the Celestar combined with its relatively large aperture make it a good choice for beginning and intermediate observers who are looking for an all-in-one telescope in an easy-to-carry package. ■

Phil Harrington's last article was "The Scoop on Scopes," in Astronomy's Explore the Universe ... 1999. *Visit his home page at http://ourworld.compuserve.com/homepages/pharrington.*

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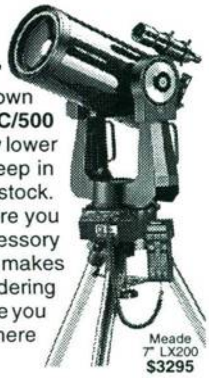

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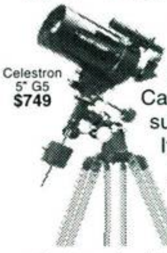

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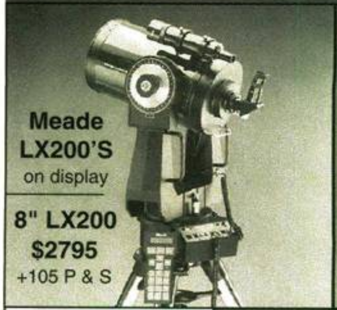

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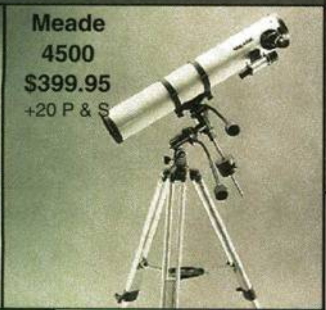

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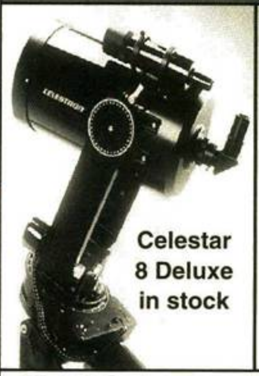

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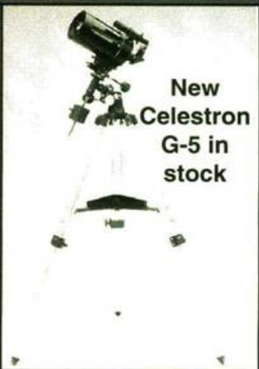

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Descent into Darkness

More than two minutes of totality await those who venture to Europe or Asia for August's solar eclipse.

BY RICHARD TALCOTT

It's time to get your passport ready. For the final time this century, the sun, moon, and Earth will align precisely and bring a total solar eclipse to a tiny part of the world. As the Caribbean Sea was last February, Europe and the Middle East are the places to be this August 11 to see nature's grandest spectacle.

Literally millions of people live in the path of totality, and more than 100 million live within about 100 miles (160 kilometers) of the path. It's anyone's guess how many of those will feel compelled to make the short trek to witness totality and how many will be satisfied simply with seeing the moon block 95 percent of the sun from view. But odds are if you're reading this magazine, a 95 percent eclipse just won't cut it.

Seeing the sun's fiery red prominences jutting above the moon's limb, the eerie, opalescent solar corona surrounding a black "hole" in the sky, or the subtle

Andreas Gada

shades of twilight ringing the entire horizon are sights no one soon forgets — or can wait to see again. Combine this visual extravaganza with the opportunity to visit some of the scenic locales of Europe or Asia and you have a dream vacation just waiting to happen.

Short but Sweet

The August eclipse doesn't offer a huge amount of time in the moon's shadow nor, in Europe at least, a guarantee of clear skies. However, other factors conspire to make this eclipse worth a trip. First, the eclipse provides up to 2 minutes and 25 seconds of totality — nowhere near the maximum possible value of about seven minutes but certainly long enough to get a good, satisfying look. Second, Europe has an excellent highway system and weather forecasts that are among the best in the world. Barring widespread inclement weather, you should be able to anticipate where the clear areas will be and then get there. As the eclipse track heads into western Asia, mobility becomes more difficult but presents less of a problem because weather prospects there look very promising.

The moon's shadow first touches Earth as day breaks over the North Atlantic. The umbra — the portion of the shadow where the sun is blocked totally from view — then lies some 180 miles (300 km) south of Nova Scotia. The probability of seeing totality from a ship there is only about 20 percent, about as low as it gets along the entire eclipse track.

The moon's penumbra — the part of the shadow where the moon partially hides the sun from view — does strike land, however, and gives residents in eastern Canada and the northeastern United States a chance to see a good partial eclipse. Parts of the Maritime Provinces will experience more than a 90 percent partial eclipse shortly after the sun rises, while Quebec sees roughly 60 to 80 percent coverage and Ontario less than that as the sun comes up in the east-northeast.

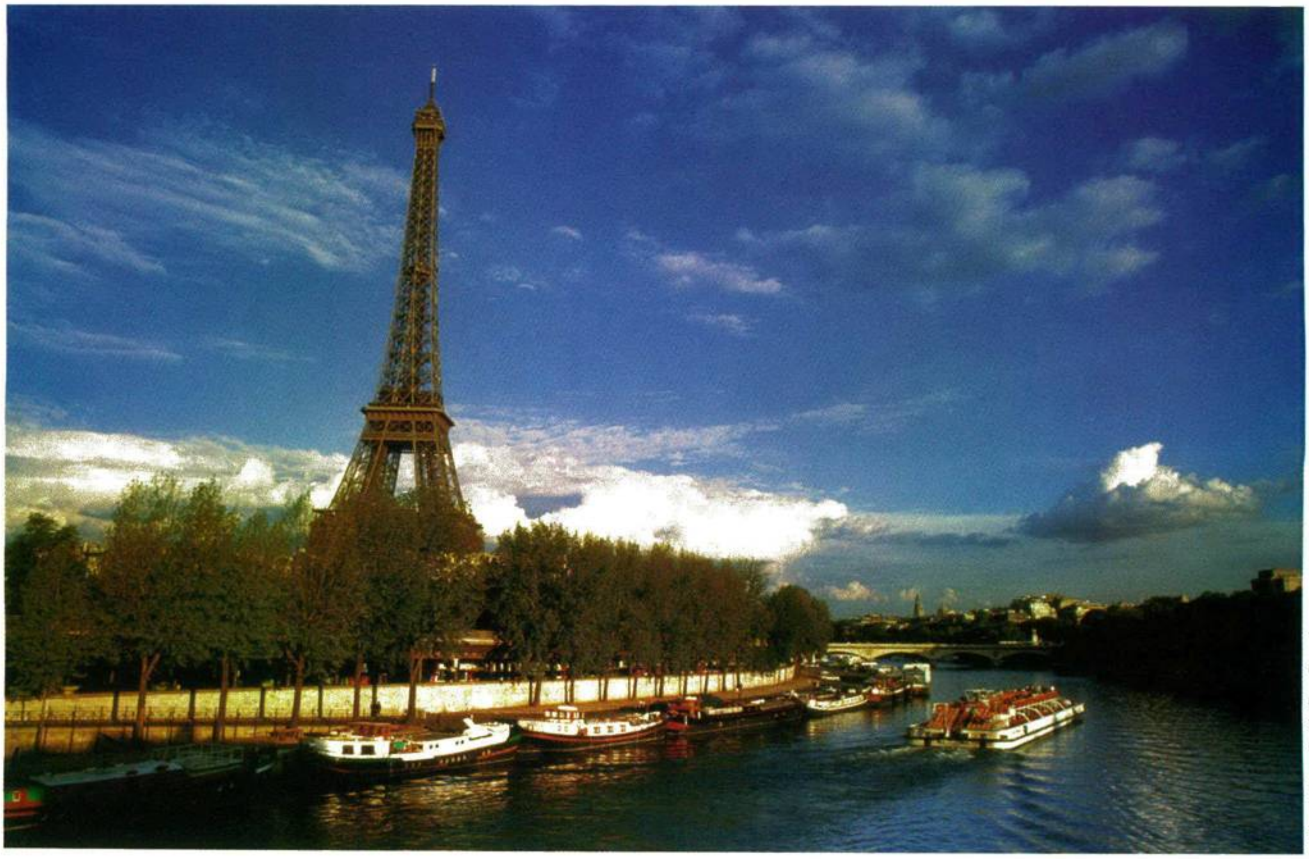
In the United States, the best views come the farther north and east you are. Residents of Maine will see the moon hiding 80 percent or more of the sun as the two bodies rise while New York City dwellers will see the sun about half-lit. The partial eclipse can be seen only from north and east of a line that runs from the Atlantic Coast where Virginia and North Carolina meet to far northwestern Pennsylvania.

A Jolly Old Time

Forty minutes after the umbral shadow touches down, it has raced across the Atlantic and makes its first landfall in the Isles of Scilly and southwestern England. By then it is late morning (about 11:10 A.M. local daylight time) and the sun lies 45° high in the southeast. Plymouth is the largest city in the umbral path, but Penzance and Falmouth are closer to the center line where totality lasts just over two minutes.

Although England has a reputation (largely deserved) for poor weather, August is the height of summer and the southwest part of the country is the sunniest. Historical

The City of Lights will see darkness at midday on August 11 when the sun's shadow sweeps across France. Paris itself sees a 99 percent partial eclipse, but totality lurks a mere 20 miles north.



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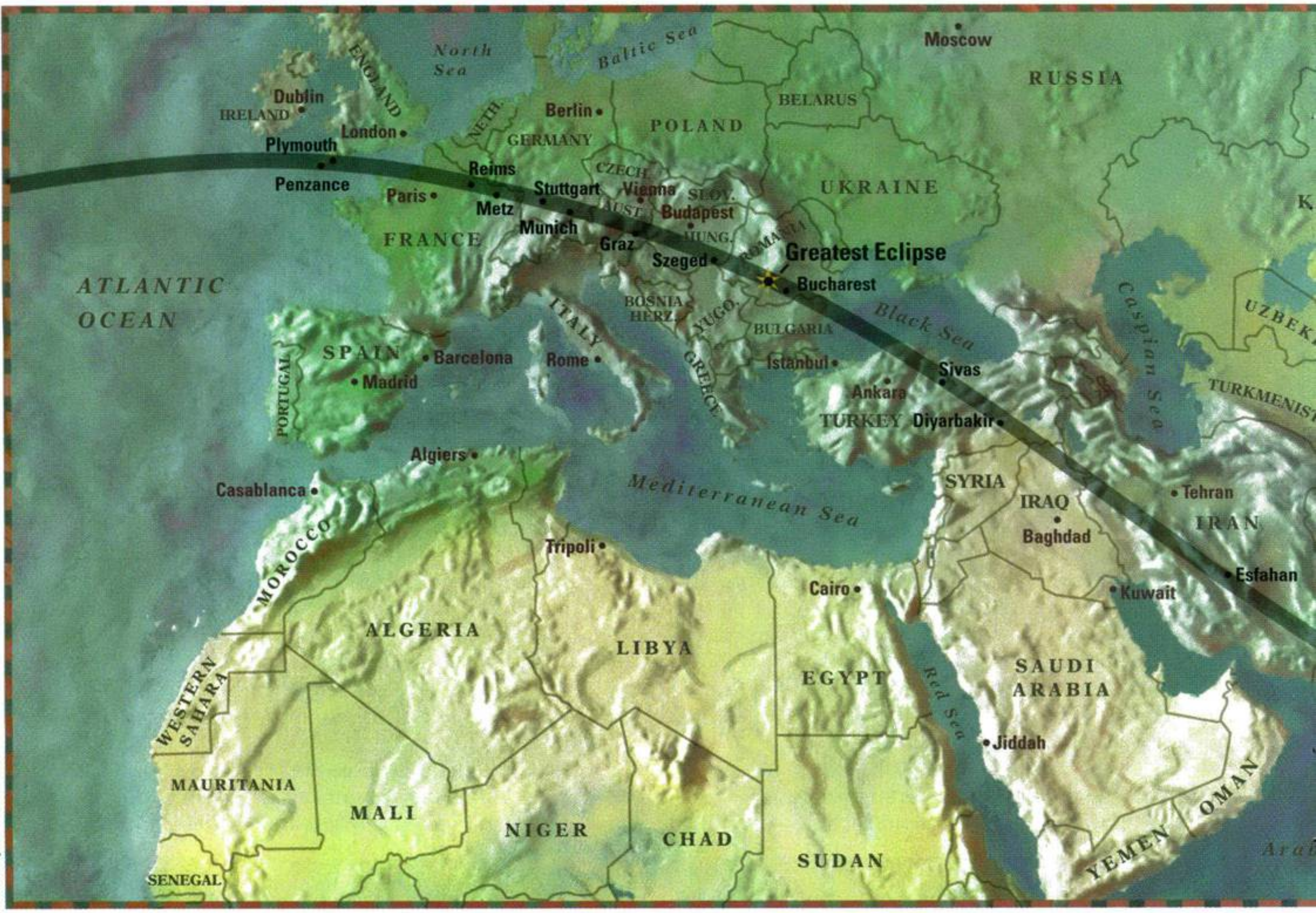
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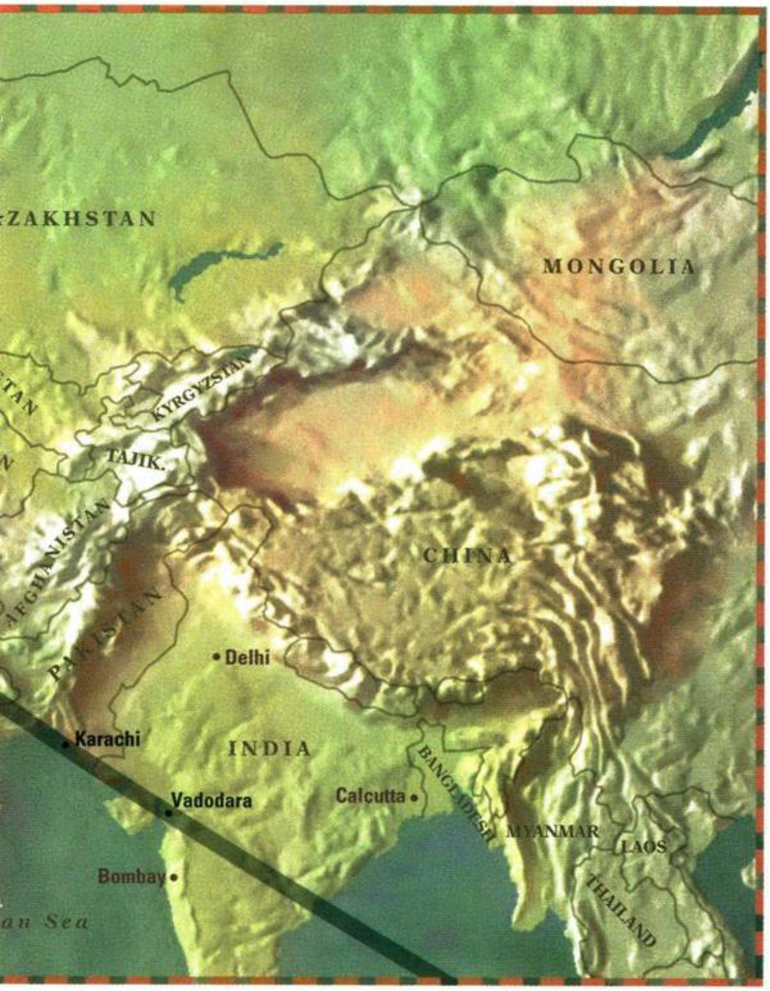
Astronomy: Elisabeth Rowan

ALONG THE TRACK

Location	Length of Totality	Local Time of Maximum Eclipse	Sun's Altitude	Sun's Azimuth	Chance of Seeing Eclipse
Penzance, England	2m02s	11:12 A.M.	46°	130°	45%
Plymouth, England	1m39s	11:14 A.M.	46°	132°	45%
Reims, France	1m59s	12:26 P.M.	52°	146°	50%
Metz, France	2m13s	12:29 P.M.	53°	150°	50%
Stuttgart, Germany	2m17s	12:34 P.M.	55°	157°	50%
Munich, Germany	2m08s	12:38 P.M.	56°	162°	50%
Salzburg, Austria	2m02s	12:41 P.M.	57°	166°	50%
Graz, Austria	1m12s	12:46 P.M.	58°	172°	55%
Szeged, Hungary	2m21s	12:55 P.M.	59°	185°	60%
Bucharest, Romania	2m22s	2:07 P.M.	59°	202°	60%
Sivas, Turkey	2m07s	2:32 P.M.	55°	234°	75%
Diyarbakir, Turkey	1m20s	2:40 P.M.	53°	242°	80%
Esfahan, Iran	1m33s	4:33 P.M.	41°	262°	95%
Karachi, Pakistan	1m13s	5:27 P.M.	22°	277°	65%
Vadodara, India	1m02s	6:02 P.M.	15°	281°	30%



weather patterns suggest a stationary observer should have about a 45 percent chance of seeing totality.

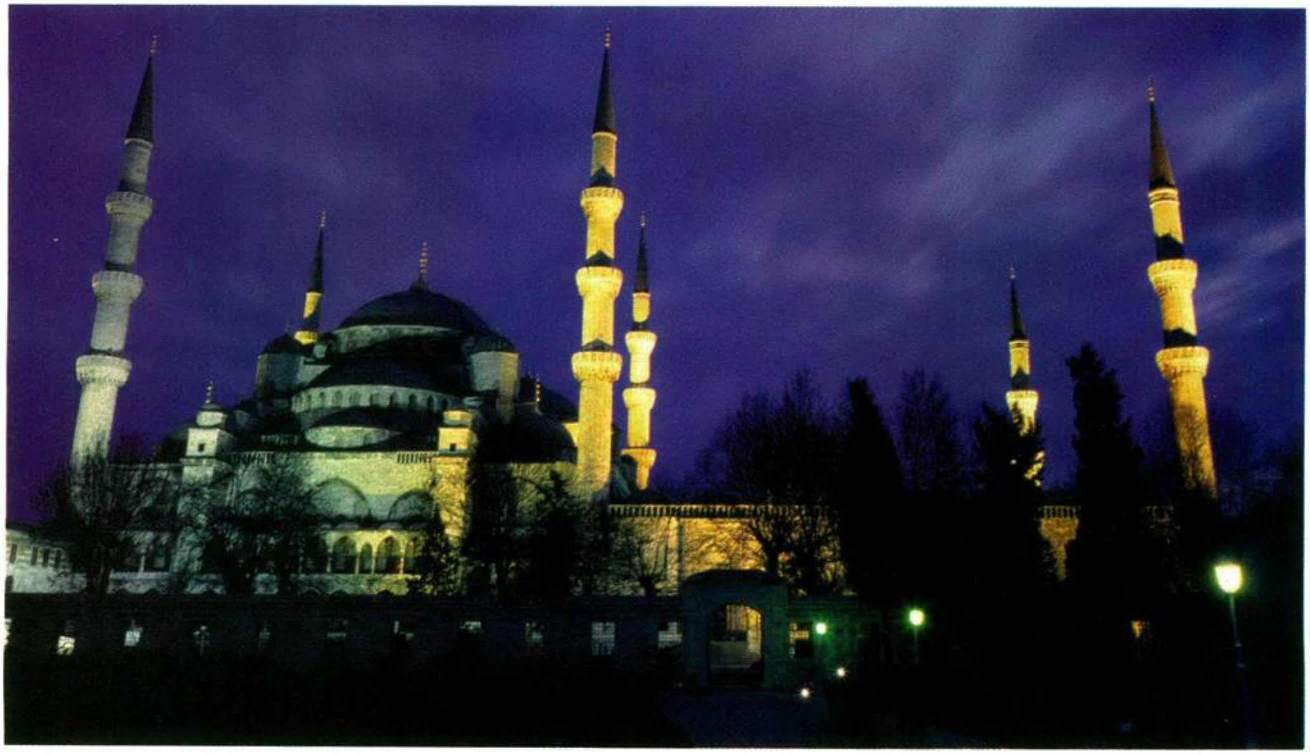
After crossing the English Channel, the shadow strikes the Normandy coast of France and begins a long trek across the heart of Europe — the first total eclipse to land here since 1961. Paris lies a scant 20 miles (30 km) south of the path of totality and will experience a 99 percent partial eclipse. Residents and visitors to the Champagne region will have far more reason to celebrate, however, after seeing a total eclipse that lasts up to 2 minutes and 15 seconds.

After cutting through southern Belgium and Luxembourg, the track then enters southern Germany, where both Stuttgart and Munich witness more than two minutes of totality. The picturesque Bavarian countryside gets swallowed in the darkness in early afternoon, around 12:40 P.M. local daylight time.

A brief visit to Mozart's birthplace in Salzburg, Austria, begins the shadow's journey across Austria and then Hungary. Like Paris, both Vienna and Budapest experience 99 percent eclipses and make good bases for excursions into the path of totality. One of the more intriguing sites for an eclipse expedition is Hungary's Lake Balaton, at 48 miles (77 km) long, the largest lake in Central Europe. A resort area known for its warm waters and sandy beaches, the lake once formed part of the border between the Ottoman and Hapsburg empires, and many ruined castles dot the surrounding hills.

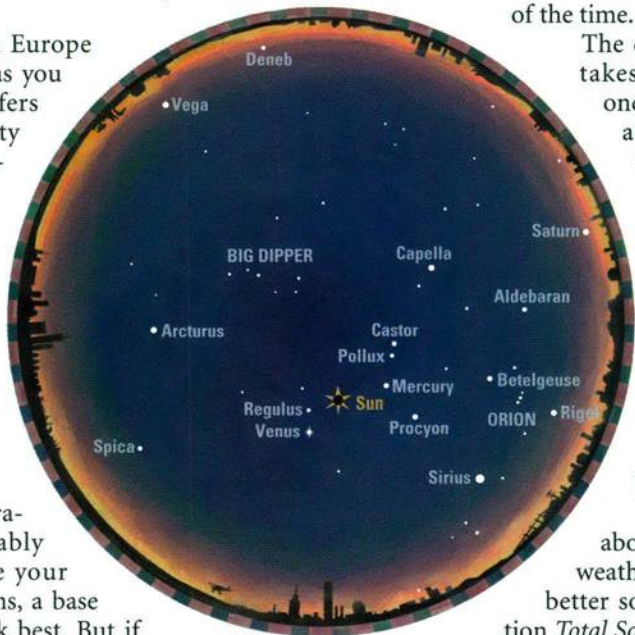
After nipping the northern edge of Yugoslavia, the track next cuts a wide swath through Romania before leaving Europe when it reaches the Black Sea near the border

East meets West at Istanbul, Turkey, an excellent starting point for eclipse excursions heading north or east along the Black Sea coast or into the Turkish interior, where the weather prospects look great.



Hugh Sitton / Tony Stone Images

between Romania and Bulgaria. Bucharest lies right on the center line and only a short distance from the point of maximum eclipse, where the sun disappears for 2 minutes and 25 seconds shortly after 2 P.M. local daylight time.



Astronomy: Elisabeth Rowan

The weather prospects in Europe slowly but steadily improve as you head farther east. France offers about a 45 percent probability of seeing totality while Germany raises that to about 50 percent. By the time the shadow reaches Romania and Bulgaria, the odds improve to about 65 percent, the same as for shipboard observers plying the typically calm waters of the Black Sea.

On to Asia

If the longest possible duration of totality and reasonably good weather prospects are your most important considerations, a base in Europe will probably work best. But if you're willing to trade a few seconds of totality for a greater likelihood of clear weather, Asia may be the better choice.

Northern Turkey offers about the same conditions as on the Black Sea coast of Europe, but as the eclipse track heads southeast, weather prospects improve. Central and southern Turkey offer a 75 to 80 percent chance of seeing the eclipse and a duration that still exceeds two minutes. After exiting Turkey, the track passes through northern Iraq and Iran, where weather prospects are best even as political prospects grow worse. The desert climate there promises temperatures soaring to 100° Fahrenheit (50° Celsius) or more and clear weather 95 percent of the time.

The peak moment during a total eclipse comes when the last vestiges of the sun's disk disappears and the solar corona comes into view.

Lance Peck

The constantly improving weather takes a quick turn for the worse once the eclipse track leaves Iran and heads into Pakistan and India. Those countries are in the midst of their wet monsoon season and the probability of seeing totality drops significantly, from about 65 percent in eastern Pakistan to 30 percent in central India — and then to less than 10 percent as the track heads out into the Bay of Bengal as it prepares to leave Earth at sunset.

For complete information about the path of the eclipse and weather prospects, you can find no better source than the NASA publication *Total Solar Eclipse of 1999 August 11* by Fred Espenak and Jay Anderson. Order from the NASA Center for AeroSpace Information at (301) 621-0390 or visit their website at http://sunearth.gsfc.nasa.gov/eclipse/TSE1999/TSE1999.html.

Round and Symmetric

If you've only seen one or two eclipses, the sun's corona will likely look different than you are used to. The sun goes through an 11-year cycle of sunspot activity that is expected to peak in the next year or so. Typically, the corona seen around solar maximum appears more circular and symmetrical than at solar minimum, when long coronal streamers emanate from the equatorial regions and delicate brushes dominate near the poles. Of course, no one knows now what the sun will be up to in August — decent predictions usually can't be made more than a week or two in advance.

The sky at mideclipse may also come as a surprise. Many skygazers are at least a little taken aback to see stars of the "wrong" season surrounding an eclipsed sun. At this summer eclipse, the sun lies in the constellation Leo, and the most prominent stars visible will be those of the late winter and early spring skies. Expect to see Sirius, Procyon, and the stars of Orion to the sun's west and the Big Dipper holding court nearly overhead. Even brighter than these stars will be brilliant Venus, shining at magnitude –4.1 some 15° east of the sun. Just nine days after the eclipse, Venus passes between the sun and Earth in a configuration known as inferior conjunction. Mercury should also be easy to spot, glowing as brightly as Procyon and lying 18° west of the sun.

So where will you be on August 11? There are lots of choices and, if you stay mobile, most offer a good chance of seeing the eclipse. The answer may come down to where you would rather spend your vacation. ■

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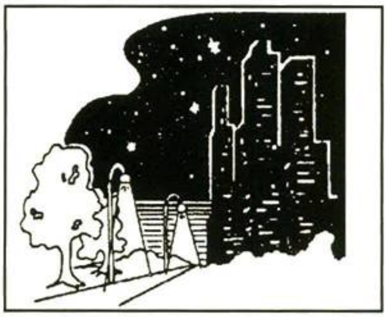

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10.5mmF.L., 65°Apparent Field $1^{1/4}$"	$269
14mm F.L., 65° Apparent Field $1^{1/4}$"	$269
21mmF.L., 65°Apparent Field $1^{1/4}$"	$269
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40mmF.L., 65°Apparent Field 2"	$299

New Lower Prices

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5X Powermate boosts magnification 5x	$168
Ranger 70mm f6.8 apchromat w/45° diag.	$640
Pronto 70mmf6.8 w/45° erecting prism	$870
Tele-Vue 85,85mm f/7 APO telescope	$1870
Bino-Vue binocular w/2x correc.	$1030
Gibraltar mount with ash wood tripod	$530
8,11,15mm Plossl . $82 — **20,25mm**	$95
32mm Plossl, widest true field in $1^{1/4}$"	$110
55mm Plossl, widest possible field	$230
2.0x or 3.0x Tele Vue Barlow Lens	$105
2" Giant Barlow – 2x	$168
4.8mm Nagler 82° field, $1^{1/4}$" eyepiece	$175
7mm Nagler, $1^{1/4}$" eyepiece, 82° field	$220
9mm Nagler, 82° field $1^{1/4}$" or 2"	$240
12mm Nagler Type II, 82° $1^{1/4}$" or 2"	$285
16mm Nagler Type II, 82° $1^{1/4}$" or 2"	$310
20mm Nagler Type II, 82° 2" only	$395
2" Paracorr visual coma corrector	$235
15mm Panoptic $1^{1/4}$", 68° field	$210
19mm Panoptic $1^{1/4}$", 68° field	$240
22mm Panoptic $1^{1/4}$"/2", 68° field	$280
27mm Panoptic 2", 68° field	$330
35mm Panoptic 2", 68° field	$365

Note: TeleVue warranty may not be valid outside USA

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The new LUMICON Binocular viewer is judged to be equal or superior to even more expensive binoviewers. Made for Lumicon by a Zeiss subcontractor, these exquisite German-made units have the highest image transmission (91%) Threaded for filters for **$749**. Both planetary and deep-sky viewers will be impressed.

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LUMICON'S piggyback mount is ideal for telescopes of 6-16" aperture. It permits both vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER, large telephoto lenses and small telescopes up to about 5 lbs.

Lumicon Adj.Piggyback Mount	$59.50

Specify telescope size: 6", 8", 10", 11", 14", 16".

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46,48,49mm	$59.00	$199.50
52,55,58,62mm	$69.00	$199.50
67,72,77mm	$79.00	$399.50
82mm (77mm+adapter)	$89.00	$415.00
Hypered 2415 film, 36 exp		$11.95

Lots of Adapters

2" adapter for C-8 Meade 2080, etc.	$29.50
2" adapter for C-80, C-100 refractor	$39.50
2" adapter for C-70, C-80F, C-102F fluorite	$39.50
2" adapter for C-6, Comet Catcher, Meade 395	$30.00

Extension Tubes

1" long $1^{1/4}$" OD thread-in extension	$12.00
$2^{1/2}$" long extension (holds $1^{1/4}$" filters)	$19.50
$4^{1/2}$" long extension for $1^{1/4}$" eyepieces	$29.00
3" long extension for 2" eyepieces*	$29.00
2" long extension for 2" eyepieces*	$29.00

Viewing Adapters

2"\1 $^{1/4}$" reducing bushing, thread 48mm*	$25.00
2" T-thread adapter, threaded 48mm*	$25.00
T-thread $1^{1/4}$" adapter	$25.00
F/10 2" or $1^{1/4}$" eyepiece viewing adapter for Giant Easy-Guider	$59.50
Low profile star diagonal eyepiece holder	$16.00
Meade 2" diagonal /Giant Easy-Guider	$39.50

**threaded to hold 48mm filters*

Low Profile Focusers

Lumicon now offers 3 different low-profile helical focusers. They stand only $1^{1/4}$" to $1^{1/2}$" above the telescope tube. Use the $1^{1/4}$" or 2" versions for viewing. Use the convenient thread-on focuser for Coulter Odyssey.

Select your desired base plate shape: Coulter Odyssey (thread on installation), Flat 7",$9^{1/2}$"OD, $12^{1/2}$"OD, 16"OD, 21"OD.

Lumicon $1^{1/4}$" Helical Focuser	$69.50
Lumicon 2" Helical Focuser ($1^{1/2}$" high)	$85.00
2" Astro systems focuser (only 2"high)	$139.00
2"/$1^{1/4}$" adapter w/48mm filter threads	$25.00
2" LUMICON Easy-Guider™	$189.50

LED flashlight $14.95

LUMICON Lumilite™ red LED flashlight
This red LED flashlight preserves night vision. 2 AA cells (incl.) will last 60 to 100 hours.

Lumilite™ red LED flashlight	$14.95
Starlite™ adjustible red LED flashlight	$24.95
Skylite™ adjustible white/red LED	$29.95

Large UV/Dust Seal

Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it on to the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron 11 and 14 and has a high-quality, coated (removable) 72mm UV filter.

Deep-Sky filter/dust seal for C-8, 2080	$199.50
UV/Dust Seal for Celestron C-8	$39.00
UV/Dust Seal for Meade 4'-8"	$39.00
UV/Dust Seal (lg.) for Meade 10"-12"	$89.50
UV/Dust Seal for Celestron 11"-14"	$89.50

Dust Covers

Protect your valuable telescope optics eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10% for 2 or more sets.

$1^{1}/_{4}$" O.D. plug, seals focuser	4/$2		
2" O.D. plug	2/$2	$3^{1}/_{2}$" O.D. plug	$1.50
$1^{1}/_{4}$", $1^{3}/_{8}$"	3/$2	$7^{1}/_{2}$"	$10
$1^{1}/_{2}$"	2/$2	$9^{1}/_{2}$", 10.4"*	$15
2"	2/$2	$12^{1}/_{2}$",$12^{7}/_{8}$"*	$20
$2^{1}/_{8}$"	2/$2	15", 15.6", 16"*	$28
$5^{1}/_{2}$"	$6	19" (DS-16)	$35
*Fits Odyssey		21" (Odyssey-II)	$35

2" Deluxe Barlow

LUMICON 1.8x Multiplier Lens	$259.00

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25mm cross-hair 1 ¼" eyepiece (12X)	$59.00
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Mounting brackets, 50mm finder	$39.50
1¼" **45°** diagonal /correct left-right views	$49.00
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Enhanced Mirrors Boost Telescope Performance

LUMICON 1.3" and 2.1" enhanced aluminum diagonal mirrors & 1 1/4" star diagonal.

LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. This extra 5-10% transmission is like adding up to an inch of aperture. The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	$39.50	1.52"	$45.00
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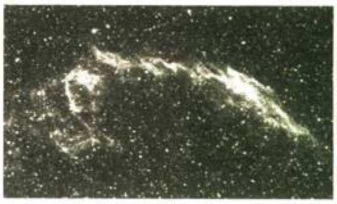
90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1 ¼" (1.32" mirror)	$99.50
2" (1.83" mirror) (see photo above)	$189.50

LUMICON FILTERS - BEST IN THE WORLD



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"From my light-polluted backyard, the view was better with my O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." *SKY & TELESCOPE, July 1995*

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"LUMICON's H-Beta Filter will show subtle features in emission nebulae that others fail to reveal. It can't be beat for the elusive Horsehead and California Nebulae." *SKY & TELESCOPE, July 1995*

Deep-Sky Filter™
BEST for Astrophotography!
"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for both color and black and white photography.

Best Wide-Band Filter!
"Based on our tests, we'd recommend a LUMICON Deep-Sky and Oxygen III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for reflection nebulae." *ASTRONOMY, February 1991*

LUMICON Multiple Filter Selector, holds 5 ¼" filters	$129; $99 if ordered w/filter
1¼" **LUMICON DEEP SKY Filter** threads into most 1¼" eyepieces	$99.50
48mm LUMICON DEEP-SKY Filter threads into most 2" eyepieces. Also fits EASY-GUIDERS	$199.50
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2" Rear Cell Filter, fits SCTs. Deep-sky, $199.50 UHC,O-III, H-Beta	$199.50
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48mm LUMICON UHC filter fits most 2" eyepieces	$199.50
Choice of any two LUMICON filters (save 7%) 1¼" $185.00 48mm	$370.00
LUMICON H-Beta Line Filter (9mm bandpass at 486nm) for the California Nebula, Horsehead Nebula ,and other extremely faint nebula. 1¼" $99.50 48mm	$199.50
Oxygen-III Filter for very faint planetary and defuse nebula, 11nm bandpass at 496nm and 501nm O-III lines. 1¼" $99.50 48mm	$199.50
Lumicon Comet (Swan Band) FIlter 1¼" $99.50 48mm	$199.50
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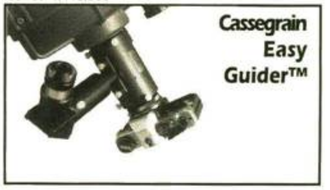
NEWTONIAN Easy-Guider	$189.50
48mm coma corrector/field flattener	$285.00
1.8X multiplier (2" Deluxe Barlow)	$259.00
3x relay diagonal	$99.50
Illuminated recticle eyepiece, pulsed	$119.50
Guider for Hasselblad	$489.00
Guider for Mamiya 645	$259.00

CASSEGRAIN Easy-Guiders
for C-8, Meade 2080, Cynamax 8, includes 50mm achromatic lens for f/6 operation (3x shorter exposures!). Superb rich field viewing too.

Cassegrain Easy-Guider	$249.00
Adapter for Hasselblad	$299.00

Mamiya 645 $119; Pentax 6x7 add $129, Pentax 645 add $149.

*US Pat. 4,448,500



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Giant Easy-Guider	$395.00

Adapter for Hasselblad $399; Mamiya 645 $149; Pentax 6x7add$139; Pentax 645 add $159.

48mm Deep-Sky Filter ordered with any Easy-Guider, (save $20)	$179.50
Illuminated recticle eyepiece	$119.50
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Model 300 Hyper-Kit
sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds $325

Model 600 Hyper-Kit
Like the Model 300, but also sensitizes 120/220 larger film and small glass plates. $395

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Temperature controller for any kit	$75
Electric Vacuum Pump, Model R-10	$325

Try PPF Hypersensitized Film
LUMICON Hypersensitized film: essential for good deep-sky astrophotography. (Deduct 10% for 3 or more rolls.)

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2415 Ultrafine B&W, red sensitive, 36 exp.	$13.95
Kodak Gold 1000 fast, fine grain, 12exp.	13.95
Fuji G800 Fine Grain color neg. 24 exp.	$13.95
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ask Astro

Center of the Universe, Urban Observing, the Moon's Recession

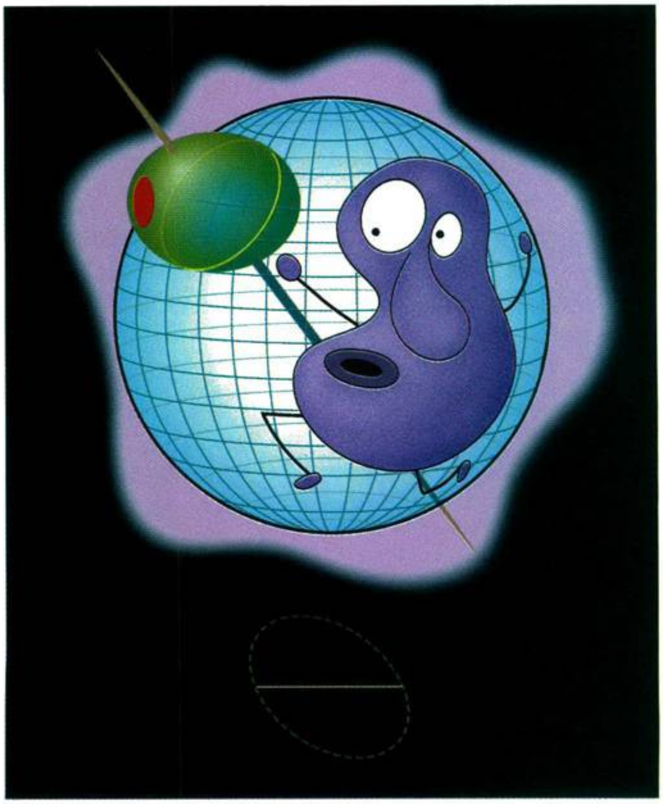
Q: Have astronomers found the center of the universe where the Big Bang took place? Where is the edge of the universe? — *Thomas Vitale, Eureka, California, and 21 others*

A: As counterintuitive as it may seem, the universe has no center, and it has no boundary. The idea of a Big Bang acting like a giant fireworks explosion hurtling matter and energy outward is pervasive but misleading. As bizarre as it sounds, it wasn't "stuff" that exploded outward, it was space itself! In essence, the Big Bang happened *everywhere*. Since the time of Einstein it has been known that space is not simply a backdrop in which we move, but an actual thing that can be measured. It has shape, it can be bent, and it can expand.

If this sounds nonsensical, think of the surface of a balloon expanding into three-dimensional space. A two-dimensional creature confined to the surface of the balloon could never find the center, because the center is located in 3-D space, and not in the 2-D space in which the creature lives. We are 3-D creatures stuck in a universe with at least four dimensions, so we cannot see the center of our universe. In fact, there's no reason why there has to even be a center anywhere.

The same reasoning holds true for the "edge" of the universe. Where is the edge of a balloon? To define an edge (or a center), you need to assume that there is something into which the universe expands. As I just explained above, that need not be true, and even if it is, we can never detect this "metaverse."

When thinking about cosmology, always remember the words of British biologist J. B. S. Haldane: "The universe is not only queerer than we suppose, it is queerer than we *can* suppose." — *Phil Plait, ACC, Inc. (check out Phil's astronomy website at http://www.badastronomy.com)*

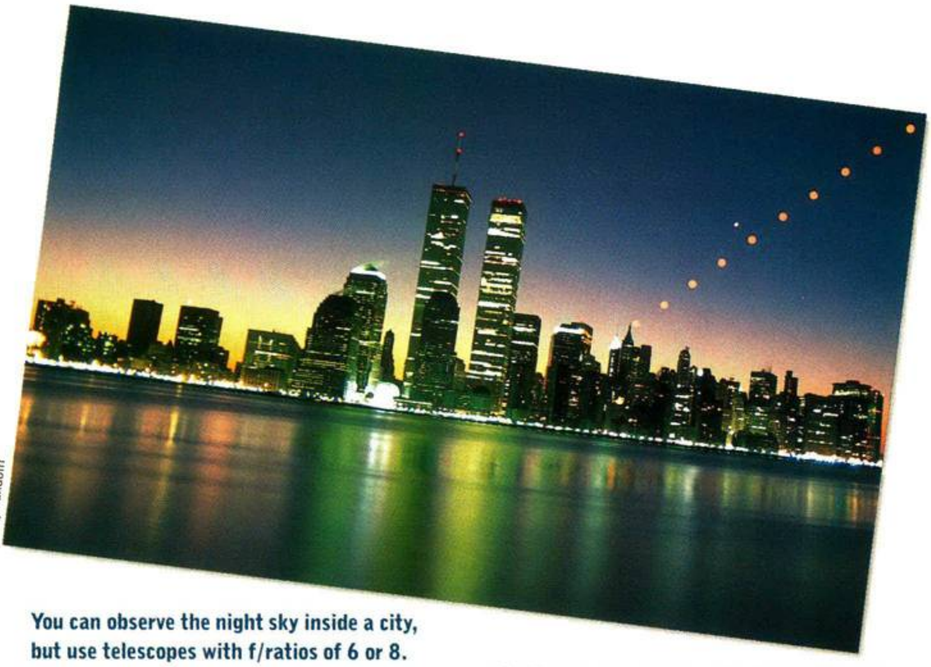


A two-dimensional creature living on the surface of a sphere would see an olive as just a (yellow) line rather than as a three-dimensional object. This creature isn't capable of finding the center of the three-dimensional sphere. Similarly, we three-dimensional creatures aren't capable of finding the center of our four-dimensional universe. *Astronomy:* Terri Field

Q: What kind of telescope would you recommend for urban astronomy that is both economical and portable and that would allow me to do some deep space viewing? — *Elsa Fitzsimmons, New York, New York; Thomas Costanzo, New York, New York; and Miguel Hernandez, Brooklyn, New York*

A: For urban observers, the name of the game is contrast. Don't buy a scope that has an f/ratio in the 4 or 5 range. They tend to offer too rich a field at low to moderate powers, capturing wider areas of low-contrast, light-polluted urban sky. Such "rich-field" scopes are better-suited for dark, rural skies. Instead, I'd opt for scopes with an f/ratio of 6 or 8. They'll still capture a decent-sized chunk of the sky at low power while offering the higher contrast views found in scopes with f/ratios in the 10 to 15 range.

You can also boost contrast by using two types of filters. Broadband filters block out wide tracts of artificial sky glare. They are often marketed as filters that combat light pollution. Narrowband filters are tuned to let in only narrow wavelengths of light from specific objects. There are several choices optimized for glowing gas clouds, galaxies, comets, or planetary nebulae. One, called an H-beta filter, favors dark dust clouds seen in silhouette against the gentle glow



Larry Landolfi

You can observe the night sky inside a city, but use telescopes with f/ratios of 6 or 8.

of background gas. But start with a broadband filter and then purchase subsequent narrowband filters after you've had a chance to survey the telescopic sky. — *John Shibley*

Q: What is the biggest star astronomers have ever found? Can I see it from the Northern Hemisphere?

— Ryan Roof, Chicago, Illinois

A: The biggest star known is a toss-up between two red supergiants in the northern constellation Cepheus, Mu Cephei and VV Cephei, with the edge probably going to VV Cephei.

Mu Cephei, at 4th magnitude, is rather easily seen in southern Cepheus. Also known as Herschel's Garnet Star, it is given away by its reddish color. From its measured angular diameter and an estimate of its distance, it has a diameter of 14 astronomical units (AU), and if placed at the sun would extend 80 percent of the way to Saturn's orbit. The distance is uncertain, so we are not sure just how big the star actually is.

VV Cephei, a 5th-magnitude star just a few degrees to the north of Mu, is a double star, the supergiant eclipsing a hot companion every 20.4 years. The supergiant is so large that the eclipse lasts 1,000 days! From the eclipse, astronomers have established a firm diameter of 17.7 AU, so VV Cephei would extend 96 percent of the way to Saturn's orbit. — *James Kaler, University of Illinois*

Q: I've read in *Astronomy* that the moon is moving away from Earth by about one inch (4 cm) a year. Why does this happen?

— Tommy Hartline, Fort Worth, Texas, and four others

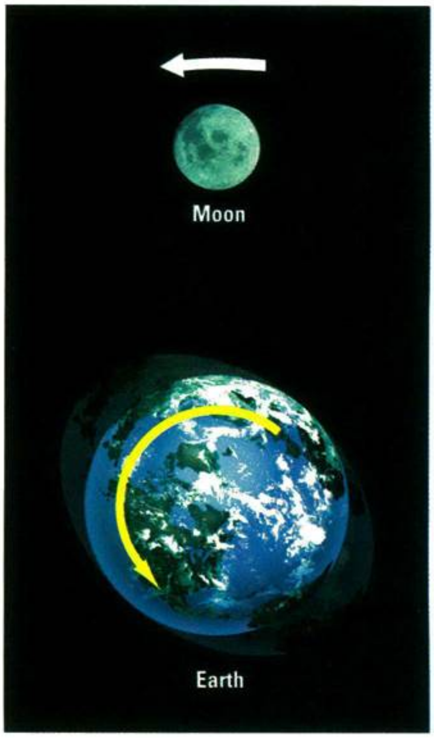
A: The Earth and moon have been locked in a celestial dance for at least 4.5 billion years. Prisoner to Earth's superior gravity, the moon is in a synchronous orbit (meaning it spins exactly once on its axis for every one revolution around Earth), forced to show the same face toward Earth for all eternity.

This situation is the result of tidal forces. The gravitational force of the moon "pulls" on Earth's oceans and crust, creating the twice-daily tides. Likewise, Earth's gravity pulls on the moon, distorting our companion so that it is slightly egg-shaped. These tidal effects produce bulges on the moon's surface, and Earth pulls on these bulges a little more than on the surrounding regions because of the concentration of mass there. Earth's constant pull on the moon's tidal bulge caused its rotation to slow down from its much faster initial spin rate to its current rate of 29.5 days.

So how does this cause the moon to recede from Earth? The tidal bulges produced on Earth by the moon are not centered at the point on Earth's surface directly below the moon, but are shifted ahead of the moon because of Earth's faster spin rate. The gravitational force of the excess mass in this displaced bulge pulls on the moon, slightly increasing its orbital velocity. In the 1600s, Johannes Kepler showed that when an object's orbital velocity increases, its orbital radius will expand; thus, the moon slowly recedes from Earth.

The effect of the moon inching away from Earth is barely noticeable on human timescales. But millions of years from now, the effects will be more tangible. The tides will be weaker because of the moon's weaker gravitational pull. The release of tidal energy in Earth's oceans and crust will continue to slow our own planet's spin and thus increase the length of our day (it is increasing at a rate of one second every 50,000 years). Our distant descendants will not be able to view a total solar eclipse, because the moon's apparent diameter will always be smaller than the sun's, making only annular eclipses possible. So in at least one respect, we live in a very lucky time! — *Jim Bell, Cornell University*

Earth rotates more rapidly than the moon orbits it, so the tidal bulge on Earth is dragged ahead of the moon's location in the sky. This bulge exerts an additional gravitational force on the moon, causing its orbital velocity to increase slightly. As the moon's orbital velocity increases, it slowly recedes from Earth at a rate of about an inch a year.



Astronomy: Terri Field

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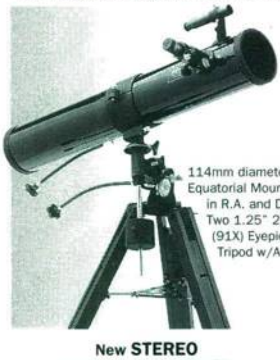

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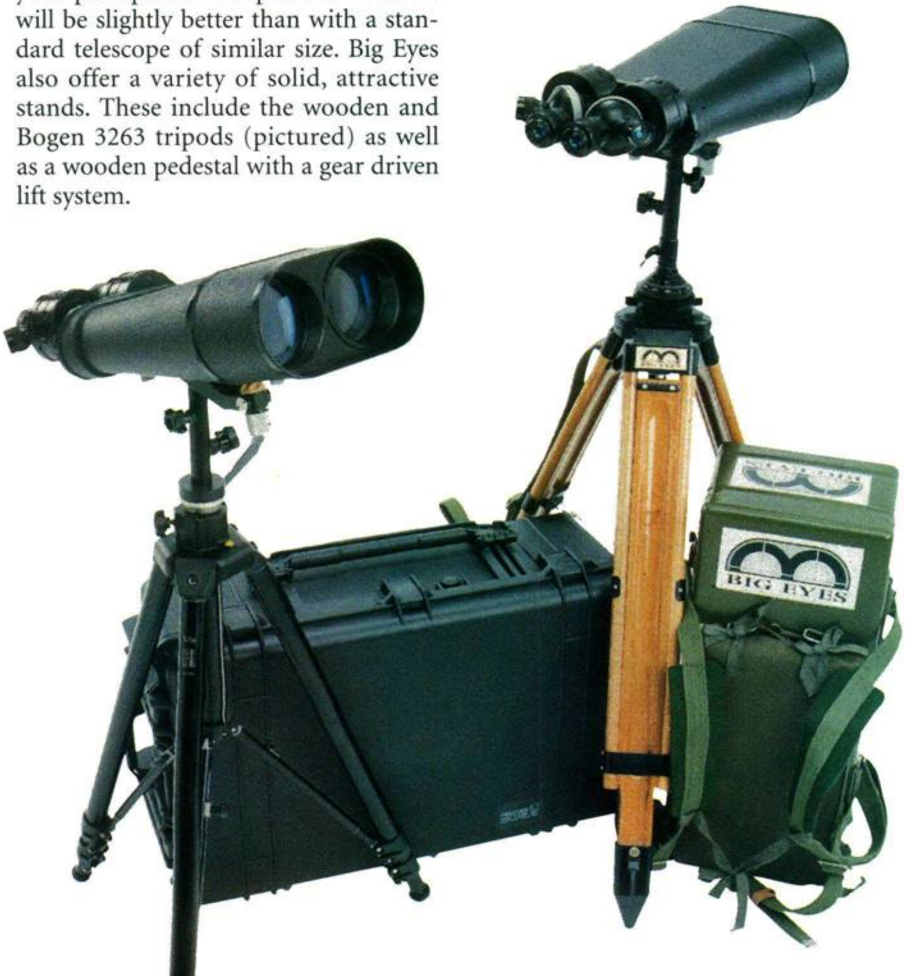
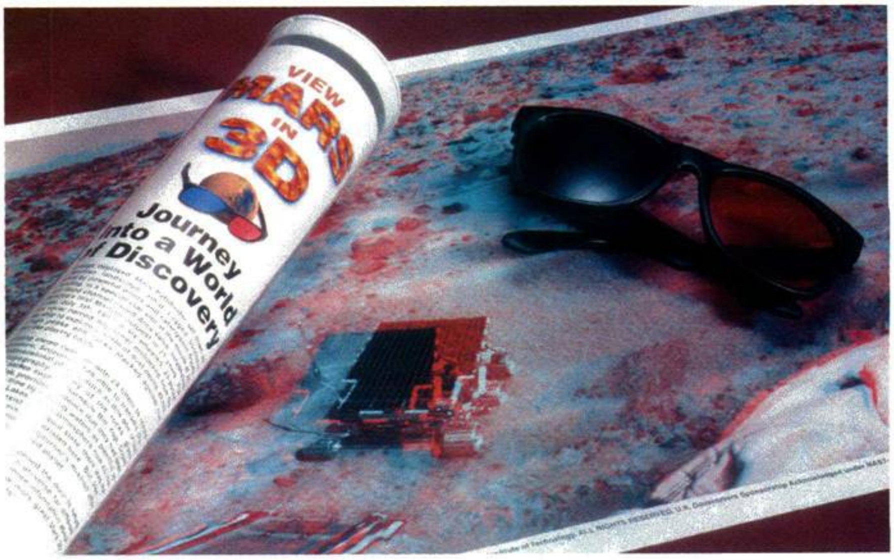
Originally designed as an artillery spotting scope for the military, Big Eyes binoculars are now being offered to hobbyists. They provide a portable means to view the heavens, while offering observers the comfort of using both of their eyes.

Big Eyes weigh 28 pounds and feature multicoated lenses, individual focusing for each eye, orange-yellow and blue-green filters, a reticle in the right tube, and two 100mm objectives — the equivalent of two 4-inch refracting telescopes. They also give the viewer the option of changing the magnification from 25x to 40x. This is accomplished by turning the right and left eyepieces 180° in either direction, similar to a microscope.

Because Big Eyes are binoculars, your perception of depth and contrast will be slightly better than with a standard telescope of similar size. Big Eyes also offer a variety of solid, attractive stands. These include the wooden and Bogen 3263 tripods (pictured) as well as a wooden pedestal with a gear driven lift system.

Big Eyes Binoculars, 121 N. Rogers, Northville, MI 48167; phone, (800) 860-6163; fax, (248) 349-5624; website, http://www.BigEyesBinoculars.com. Big Eyes 65-25-40 Binoculars $2,595. Wooden Tripod: $220. Bogen 3263 Tripod: $315. Wooden Pedestal: $1,200.





View Mars in 3-D

▶ With its airbags deployed, Mars Pathfinder set down on the martian landscape amid rugged boulders sculpted by powerful winds and cataclysmic floods. The landing, in a spectacular site at the mouth of an ancient flood channel called Ares Vallis, established humankind's first martian outpost in 21 years. The next day, July 5, 1997, a six-wheeled, 23-pound robotic rover named Sojourner embarked from the mother ship to explore a world of dust devils, mountain peaks, and rocks stacked against one another like toppled dominoes. Sojourner's stereo cameras with their 24 filters were used to record the craft's adventure.

Now Rainbow Symphony offers one of these spectacular three-dimensional images in a large 39" by 10" poster that includes a pair of rigid-framed 3-D glasses. Though the image does not contain the entire 360° view, it has been processed to bring out further detail in the rolling terrain and includes the Twin Peaks and well-worn boulders named Barnacle Bill, Yogi, Couch Rock, and Moe — each wears the scars of the planet's watery past.

Rainbow Symphony, 6860 Canby Ave. #120, Reseda, CA 91335; phone, (818) 707-8400; fax, (818) 708-8470; e-mail, mars3d@rainbowsymphony.com; website, http://www.rainbowsymphony.com. Mars 3-D Poster and Proview Glasses: $15.95.

Mars Meets Bach

▶ Music Crest Productions has united art and science in its new release, *Winds of Mars*. This classical recording features 17 works for solo piano by Johann Sebastian Bach, performed by Roderick Kettlewell, the Juilliard-trained artistic director of the Bach Society of Minnesota.

The compact disc features digital wind sounds culled from the data gathered by Mars Pathfinder. Winds from Mars can be heard throughout the recording — from gentle breezes to mercurial gusts or a swift, raging dust devil. It is an environmental/musical presentation in four acts, each with its own flavor. Selections include: *Sleepers Wake*, *Be Thou with Me*, prelude in C major and prelude in F minor from *The Well-tempered Clavier*, and others.

Winds of Mars
and the music of Johann Sebastian Bach

The Winds of Mars is the brainchild of producer Kelvin Miller. While attending a space exploration conference, Miller heard a lecture by Edward Stone, director of the Jet Propulsion Laboratory in Pasadena, California. Stone described Mars Pathfinder's weather station and its instruments. He told the audience that although the weather station wasn't recording the winds in the traditional way (with a microphone), he speculated it would be possible to generate the sounds using a computer. The music of Bach entered Miller's mind and the rest is history.

Music Crest Productions, P. O. Box 2945, Minneapolis, MN 55402-0945; phone, (612) 338-5461; fax, (612) 338-4769; e-mail, windsofmars@premiergallery.com; website, http://www.windsofmars.com. Winds of Mars*: $17.99.*

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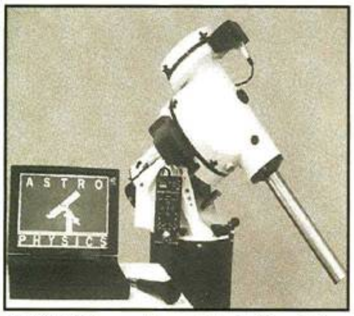

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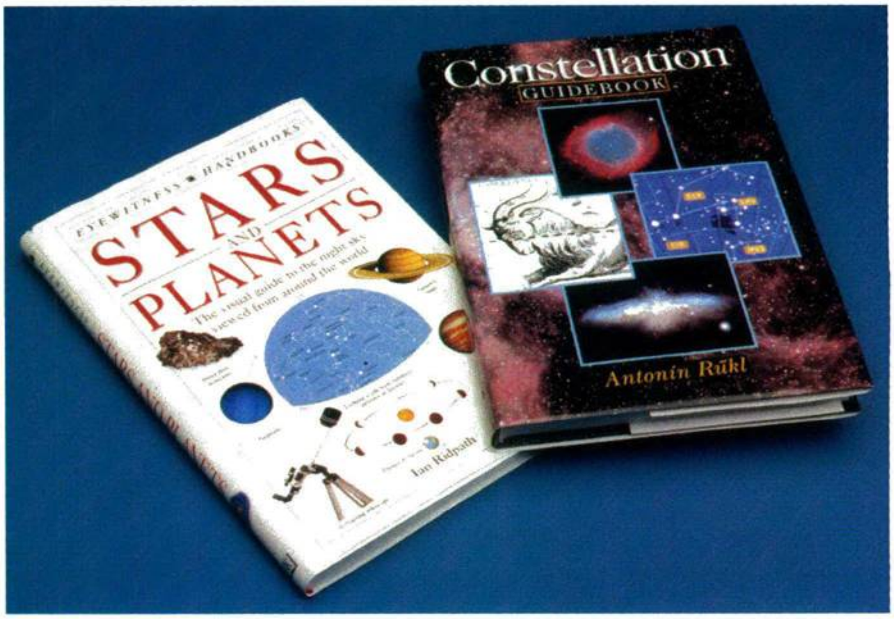

With springtime nights offering warmer temperatures, more observers will begin venturing out under the stars. Maybe this season you vow to spend a little more time looking at the planets. Or perhaps you promised yourself to take in a few more nebulae — at least learn where they are and when you can see them best.

The key to finding more planets and galaxies is learning the constellations. If you agree, then we have two good books for you. They are *Stars and Planets* by Ian Ridpath and *Constellation Guidebook* by Antonín Rükl. These books are small (roughly 6" by 8"), are handy to read and carry around, contain lots of good, solid observing information and are filled with helpful illustrations and often colorful diagrams.

Stars and Planets

Ian Ridpath, 224 pages, DK Publishing, New York, 1998; ISBN 0-7894-3521-7; softcover; $18.95.

► In the tradition of DK Publishing, this book has stark white pages adorned with rich, colorful photographs and simple, jargon-free illustrations. It's divided into four parts: an introduction to astronomy, a guide to the solar system, a catalog of constellations, and a monthly sky guide.

The introduction and the chapter on the solar system provide good overviews, defining the universe and our place in it. Pages within these two sections explain the different types of stars, for example, and where we lie in the solar system. The information here is a tad rudimentary for the amateur astronomer, but both sections do contain helpful explanations of topics not immediately understood by the neophyte astronomer such as retrograde, scale, the celestial sphere, and apparent magnitude.

The section on constellations contains 88 entries of the formations, all arranged in alphabetical order. Each entry provides a detailed chart of the constellation along with the stars around it. A small paragraph introduces the constellation and gives its mythological origin. Andromeda, for example, "depicts the princess in Greek myth who was chained to a rock as a sacrifice to a sea monster. ..."

Features of interest in the region are called to attention in both text and in spectacular photographs. An image of M31, the Andromeda Galaxy, shows the object as a rich, orange oval against a velvety dark sky. A narrow banner running along the top and bottom of the page provide key information such as when the object is highest in the sky and how large it appears. For instance, Andromeda is highest at 10 P.M. between October and November, so this is the best time to look for it. Shaded regions on a small map of the world indicate who gets a full view.

The last section of the guidebook is filled with monthly sky charts with a separate chart for each hemisphere. It's amazing how much useful information is packed onto each page here. You'll find times of sunrise and sunset, charts that show all stars brighter than magnitude 3, a key to star magnitudes, a description of stars and deep-sky objects, photos of easily recognizable objects, and text that summarizes notable objects of the month.

Constellation Guidebook

Antonín Rükl, 224 pages, Sterling Publishing Co., New York, 1998; ISBN 0-8069-4299-1; $17.95.

► If you're looking for a book devoted solely to the constellations, then check out the *Constellation Guidebook*. This slick, glossy-papered book gives more time and space to the 88 starry formations than *Stars and Planets*. As a

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THAT'S THE NORTH STAR
SEE THAT STAR UP THERE? THAT'S THE SOUTH STAR...
IF YOU LISTEN TO ME, YOU'LL NEVER BE LOST IN THE WOODS
I'M THINKING OF NEVER LEAVING THE FRONT YARD!
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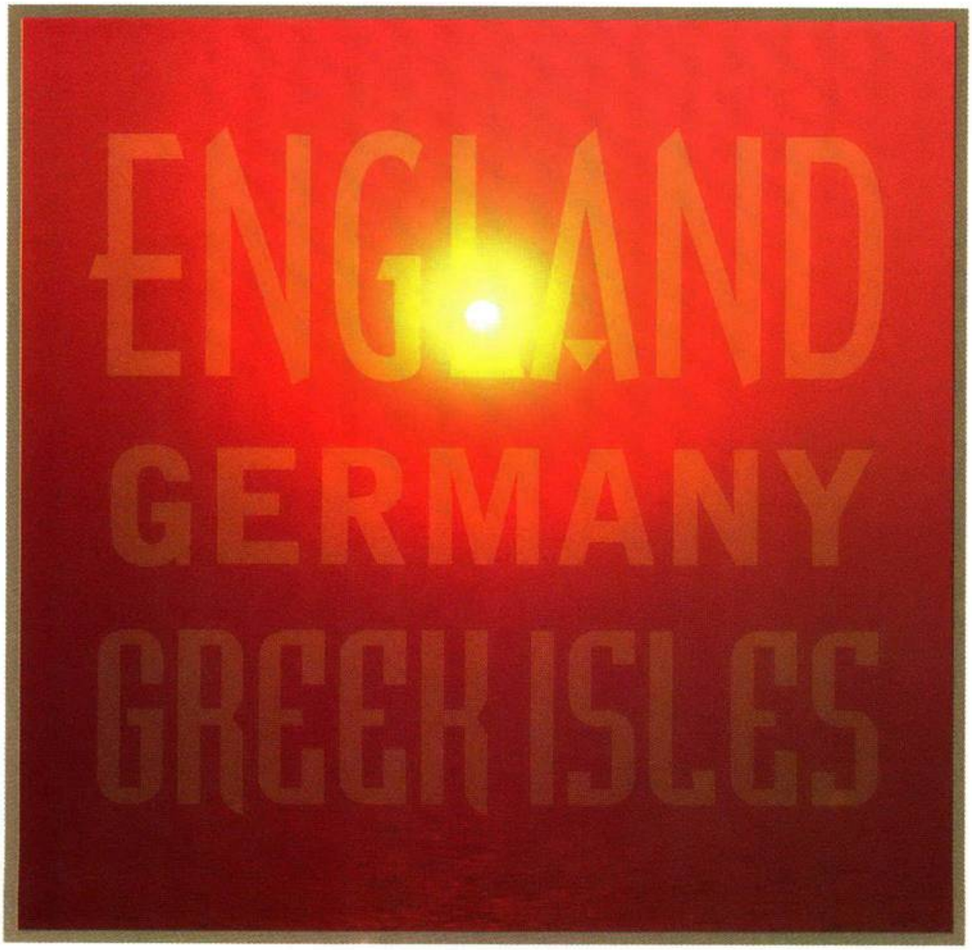
Astronomy Magazine presents

1999 solar eclipse tours



Come join ***Astronomy*** Magazine on one of its four amazing solar eclipse tours being held August 6-15, 1999. Along with catching one of the most spectacular views of the last solar eclipse of the 20th century, you will experience the magnificent sights and sounds of such wonderful places as England, Germany, and the Greek Isles in the process. Choose your favorite destination today.

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result, the material is broken down in more finely tuned chapters.

The first describes where, when, and how you can find constellations. It explains in detail terms such as the celestial sphere, the celestial equator, zenith, declination, right ascension, and circumpolar stars. Black and white illustrations give the terms visual perspective. A short section on the zodiac follows this chapter, explaining how the ecliptic passes through the twelve — actually thirteen — constellations.

The meat of the book resides within its so-called celestial guide. This portion focuses on deep-sky objects, celestial maps, and constellation maps. You'll find extensive explanations about stars and their magnitudes, spectra, and luminosities. The author also provides many examples of star clusters, nebulae, and galaxies. Colorful photographs and diagrams help support each description. An air-brushed illustration shows the different (11 in this case) types of galaxies.

The celestial maps that follow go into excellent detail. The book contains two sets of star maps: general maps of the whole sky and maps of individual constellations. The general maps will help orient you to the sky, while the constellation maps give you a close-up view of your region of choice, the stars, and deep-sky objects you can find there.

Like most constellation maps, these are colored blue with black text. But two full pages are generally devoted to each of the 88 constellations, so there's plenty of room for other helpful diagrams and beautiful photographs. For example, an orientation map on each spread shows the position of the constellation on the celestial sphere. There's also a line drawing of the Big Dipper on each page to provide a size comparison of the constellation featured. The text on each spread describes the myth associated with the constellation and also highlights objects of interest.

The book ends with an index of constellations and a glossary of terms. The glossary is not very extensive — about four pages, but certainly adequate for a book that packs a lot of information into a tight space.

— *Tracy Staedter*

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▶ Educators, parents, and inquisitive adults will enjoy Bamboole's latest CD-ROM, *Impact: Ground Zero.* This in-depth, interactive program features the science behind comet and asteroid impacts on Earth. It explores, in detail, the massive comet strike that killed the dinosaurs some 65 million years ago, while also investigating today's world and the consequences of a comet larger than Mount Everest smashing into Los Angeles or Tokyo.

The program is narrated by Richard Gebhardt, a frequent narrator on the Discovery Channel and PBS science programs, and includes interviews with leading researchers in the fields of physics, geology, paleontology, astrobiology, and chemistry. NASA experts also discuss their defense plans and efforts that might prevent an impact.

Hundreds of beautiful photographs and drawings from the NASA archives illustrate the disc, and artistic renditions by Joe Tucciarone are also scattered throughout. For those in search of specific events, there is a timeline as well as a research library with over 200 pages of text to review.

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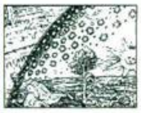

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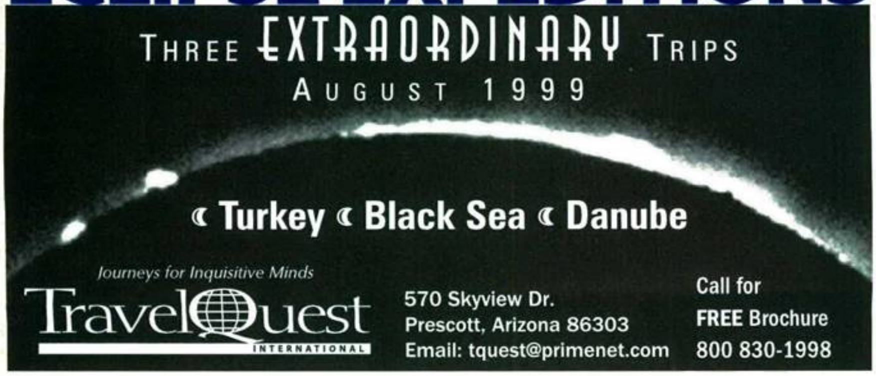

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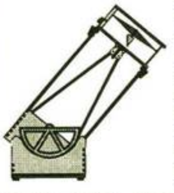

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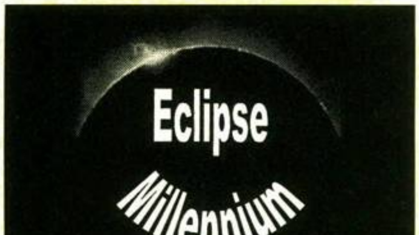

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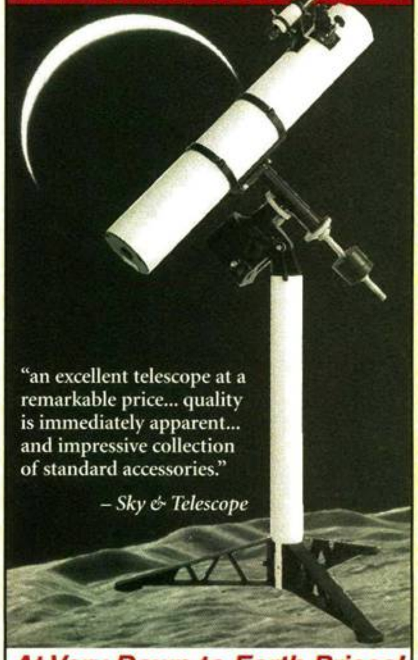

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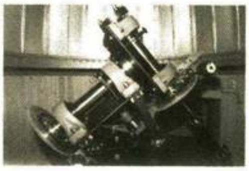

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The Lunar and Planetary Science Conference will be held March 15–19 in Houston, Texas.

New results in planetary science will be the focus of the 30th **Lunar and Planetary Science Conference** taking place in Houston, Texas, at the NASA Johnson Space Center, **March 15–19**. Researchers in astronomy, petrology, geochemistry, geophysics, and geology will present their latest findings. For more information, contact LeBecca Simmons, LPI Publications and Program Services Department, 3600 Bay Area Boulevard, Houston, TX 77058; (281) 486-2158; e-mail, simmons@lpi.jsc.nasa.gov; website, http://cass.jsc.nasa.gov/lpi.html.

Dark skies over the Davis Mountains of West Texas are expected to draw more than 700 people to the **Texas Star Party, May 9–16**, at the Prude Ranch, near Fort Davis, Texas. Preregistration is under way. Contact the TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002; e-mail, kastro@aol.com; website, http://www.metronet.com/~tsp/index1.html.

We've received notice of two cancellations. The **Winter Star Party**, originally slated for February 15-21, **has been cancelled** due to severe damage to Camp Wesumkee by Hurricane Georges. The WSP will return next year — plans are already in the works for the Winter Star Party 2000. Also, the **AstroPhoto Seminar**, originally scheduled for March 6 at Moorpark College in California, **has been cancelled**.

MARCH 12–14

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▶ Domein De Maat, Mol-Postel, Belgium. Organized by the Andromeda Astronomical Society Mol. Contact Josch Hambsch, Oude Bleken 12, B-2400 Mol; telephone, 32 (0) 14-310507; e-mail, hambsch@ irmm.jrc.be.

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▶ NASA Johnson Space Center, Houston, Texas. Cosponsored by the Lunar and Planetary Institute and the NASA Johnson Space Center. Contact LeBecca Simmons, LPI Publications and Program Services Department, 3600 Bay Area Boulevard, Houston, TX 77058; (281) 486-2158; e-mail, simmons@lpi.jsc.nasa.gov; website, http://cass.jsc.nasa.gov/lpi.html.

MARCH 19–20

New Astronomers' Weekend

▶ Pine Mountain State Resort Park, Pineville, Kentucky. Registration fee $15; deadline March 12. Contact Dean Henson, e-mail, RocketMan@kih.net or Pine Mountain State Resort Park, 1050 State Park Road, Pineville, KY 40977; (606) 337-3066 or toll-free, (800) 325-1712.

MARCH 19–21

Telescope Optics Workshop

▶ Western Washington University, Bellingham, Washington. Contact Kreig McBride, 402 East Horton Road, Bellingham, WA 98226; e-mail, kmcbride@memes.com; website, http://www.wwu.edu/~skywise/optics.html.

MARCH 19–22

South Pacific Star Party

▶ Wiruna, near Ilford, New South Wales, Australia. Contact the Astronomical Society of New South Wales, GPO Box 1123, Sydney 1043, NSW, Australia; e-mail, asnsw@ozemail.com.au; website, http://www.ozemail.com.au/~asnsw/spsp/spsp.htm.

APRIL 14–17

Mid-South Star Gaze

▶ Rainwater Observatory, French Camp, Mississippi. Contact James Hill, (601) 547-6865; website, http://rainwater.astronomers.org.

APRIL 15–18

Peach State Star Gaze

▶ Indian Springs State Park, Camp McIntosh, near Jackson, Georgia. Contact Ken Poshedly, 1741 Bruckner Court, Snellville, GA 30078-2784; (770) 979-9842; e-mail, ken.poshedly@mindspring.com.

APRIL 16–17

Central Texas Star Party

▶ Pedernales Falls State Park, Johnson City, Texas. Contact the Austin Astronomical Society, P. O. Box 12831, Austin, TX 78711; David Sands, (512) 252-2966; website, http://www.main.org/aas/. Make camping arrangements through State Park Reservations, (800) 389-8900.

APRIL 16–18

Delmarva Star Gaze

▶ Tuckahoe State Park, Queen Anne, Maryland. Sponsored by the Delmarva Stargazers. Contact Lyle Jones, (302) 736-9842; e-mail, lyjones@state.de.us; website, http://www.delmarvastargazers.org.

APRIL 16–19

Adult Beginning and Advanced Astronomy Camp

▶ Mount Lemmon and Bigelow Observatories, University of Arizona, Tuscon, Arizona. Contact Don McCarthy, 933 North Cherry Avenue, Tucson, AZ 85721; (520) 621-4079; e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astro_camp.

APRIL 23–24

NIAGfest Astronomy Convention and GreatCon

▶ Camp Crosley, North Webster, Indiana. Sponsored by the Northern Indiana Astronomical Group and the Great Lakes Region Astronomical League. Contact Mike Beaver, (219) 594-2355 (eves.); e-mail, michael.beaver@kconline.com; James Tague, 3370 East Kenway Drive, Warsaw, IN 46580; website, http://clubs.kconline.com/was/niag.htm.

APRIL 30–MAY 1

North Central Regional Astronomical League Convention

▶ Sheraton Four Points Hotel, Cedar Rapids, Iowa. Hosted by the Cedar Amateur Astronomers. Contact Deb Bonser, 1009 Harding Street, Tama, IA 52339; (515) 484-5235; e-mail, deb.bonser@usa.net.

MAY 9–16

Texas Star Party

▶ Prude Ranch, Fort Davis, Texas. Contact the TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002; e-mail, kastro@aol.com.

MAY 30–JUNE 3

American Astronomical Society Convention

▶ Chicago, Illinois. Hosted by the University of Chicago. Contact Richard Kron, Yerkes Observatory, 373 West Geneva Street, Williams Bay, WI 53191; (414) 245-5555; e-mail, rich@oddjob.uchicago.edu; website, www.aas.org.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or email tconley@astronomy.com. Look for additional events at http://www.astronomy.com.

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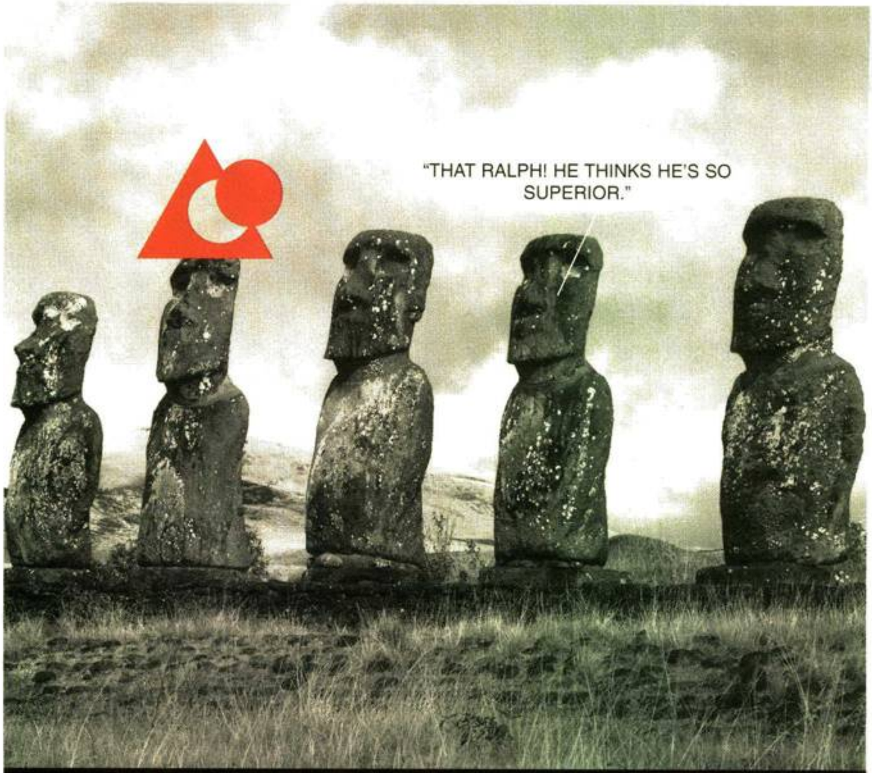

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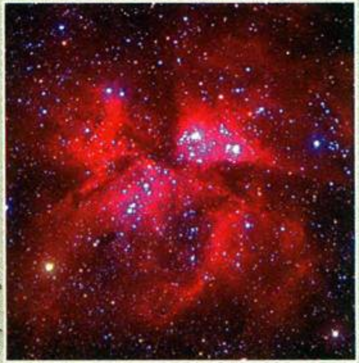

Jerry Lodriguss

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METEOR SHOWERS

A Quasi-Storm from the Leonids

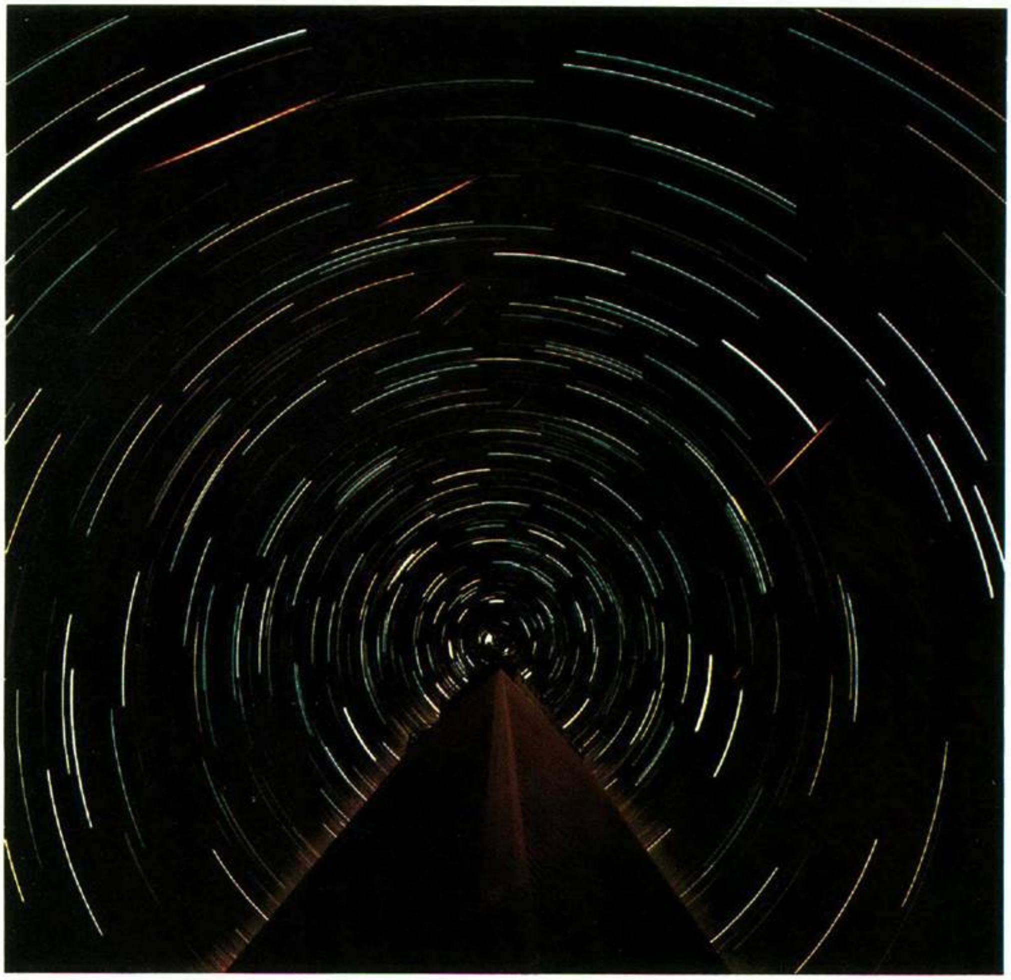
▶ The question pulsed through the astronomical community and splashed into the mass media: Would the 1998 Leonid meteor shower produce a storm of incredibly high activity? As it turned out, yes, sort of — it generated elevated numbers of bright meteors relative to most years.

On the morning of November 17, all eyes were gazing skyward. About every 33 years, the shower, a byproduct of the orbital debris of Comet 55P/Tempel-Tuttle, offers heightened activity due to Earth's passing through the main particle stream of the comet's orbit.

In 1833, the record year, as many as 150,000 meteors per hour were reported. In 1966, the latest year of substantial activity, observers in the United States reported at least 100,000 meteors per hour, and many were bright fireballs.

This year, the situation favored Japan and eastern Asia, where the entrance through the main particle stream coincided with nighttime hours.

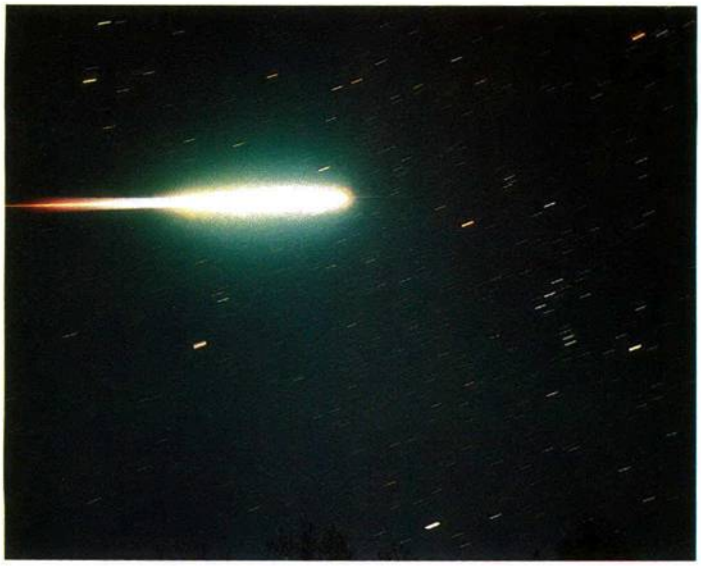
Still, observers around the world reported high rates of bright meteors. From the Blue Ridge mountains of central Virginia, Kevin Jones observed 409 meteors during 247 minutes on the early morning of the 17th, 358 of which were Leonids. "The first Leonid blazed across the sky before



Leonids Whiz over the McMath-Pierce Scope on Kitt Peak

WILLIAM LIVINGSTON

(40mm lens, Ektachrome 100s film, 70-minute exposure taken November 17, 1998)



A Magnitude –12 Leonid Fireball Pairs with Orion

RICK SCHMIDT

(24mm lens at f/2.8, ISO 400 film, 10-minute exposure taken November 17, 1998) the radiant came up," says Jones, "a fireball that shot across 120° of sky started at the horizon, climbed up to the zenith, and faded as it dropped downward."

From a site south of Phoenix at Vekol Ranch, Arizona, Jack Jones of the Saguaro Astronomy Club and others witnessed more than 1,200 meteors between midnight and 6 A.M. on the 17th. "Most were between magnitudes 2 to –6," says Jones, "with many fireballs, and a few as bright as the full moon, lighting up the ground around us." Their hourly counts increased toward dawn and peaked at 308 per hour.

From Mauna Kea, Hawaii, George Gliba braved a below-freezing wind chill, watching the skies with members of the Hawaiian Astronomical Society. They saw 322 Leonids in 195 minutes, not a storm per se but "a good show," according to Gliba.

No storm rivaling 1966 took place, but a quasi-storm did occur. The real surprise was that it took place earlier than expected: Astronomers working on the Isaac Newton Telescope in the Canary Islands reported meteor rates as high as 2,000 per hour as dawn broke there on November 17.

"The number of bright meteors is astounding," wrote Alan Fitzsimmons, an astronomer working on the INT. "Every couple of minutes you get a bright flash behind you, and you turn around to see the trail fading." If you missed this year's show, hope is not lost. Meteor watchers can still look for increased activity during next year's Leonid shower. — *Dave Eicher*

Leonid Meteors Penetrate Perseus

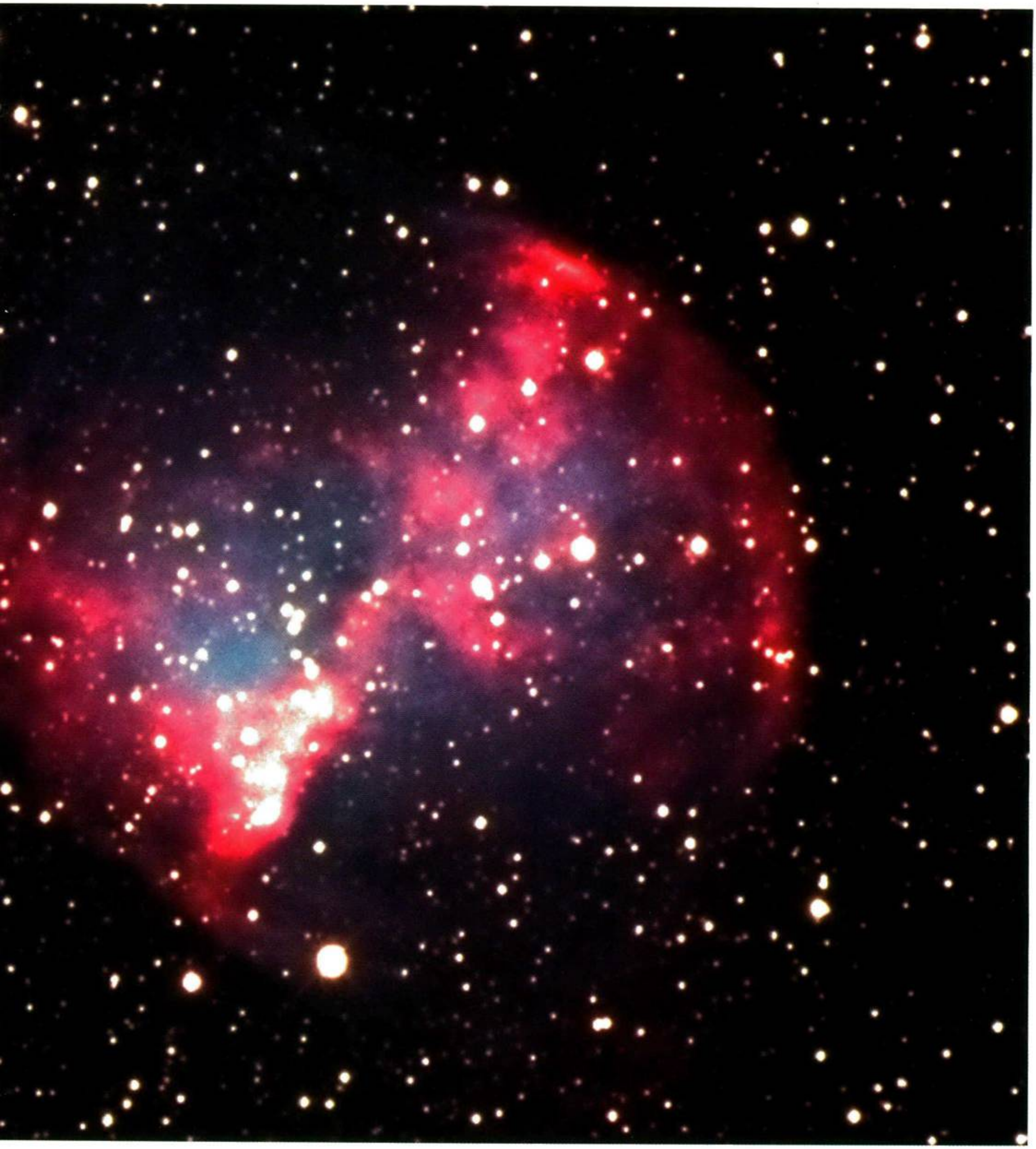
G. PARKIN

(35mm lens at f/2, Fuji 800 film, 10-minute exposure taken November 17, 1998)

A Leonid Zips Past the Big Dipper

FRANK ZULLO

(28mm lens at f/4, Fuji Super G 800 film, 23-minute exposure taken November 17, 1998)



The Dumbbell Nebula (M27) in Vulpecula

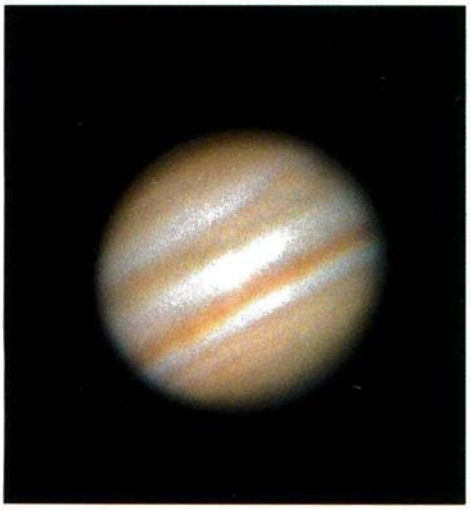
WILLIAM MCLAUGHLIN

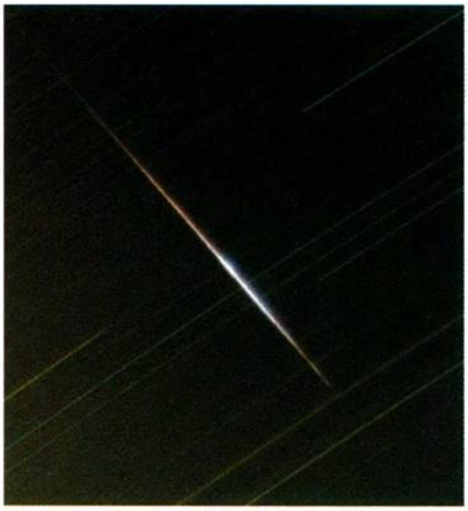
(12.5-inch Cassegrain at f/6, SBIG ST-7 CCD camera)

Jupiter's Ochre Disk

ANTHONY B. OBRA

(60-inch Mt. Wilson reflector, Kodak 100 film, 1/4-second exposure taken August 22, 1998)





A Leonid Crosses Star Trails

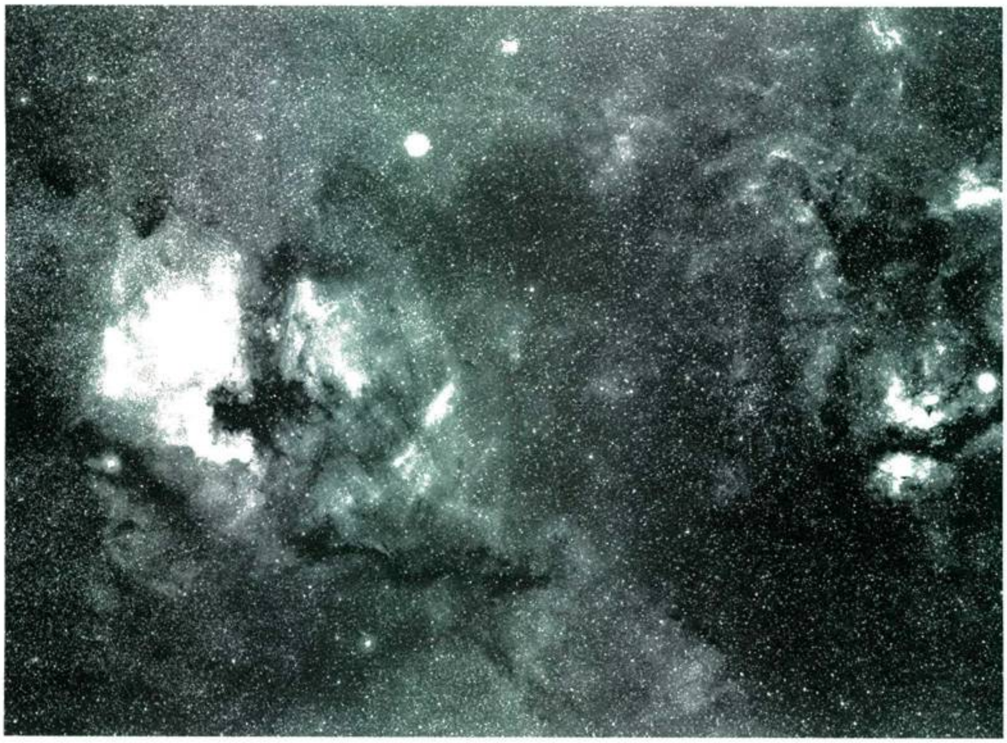
STEVE R. JACKSON

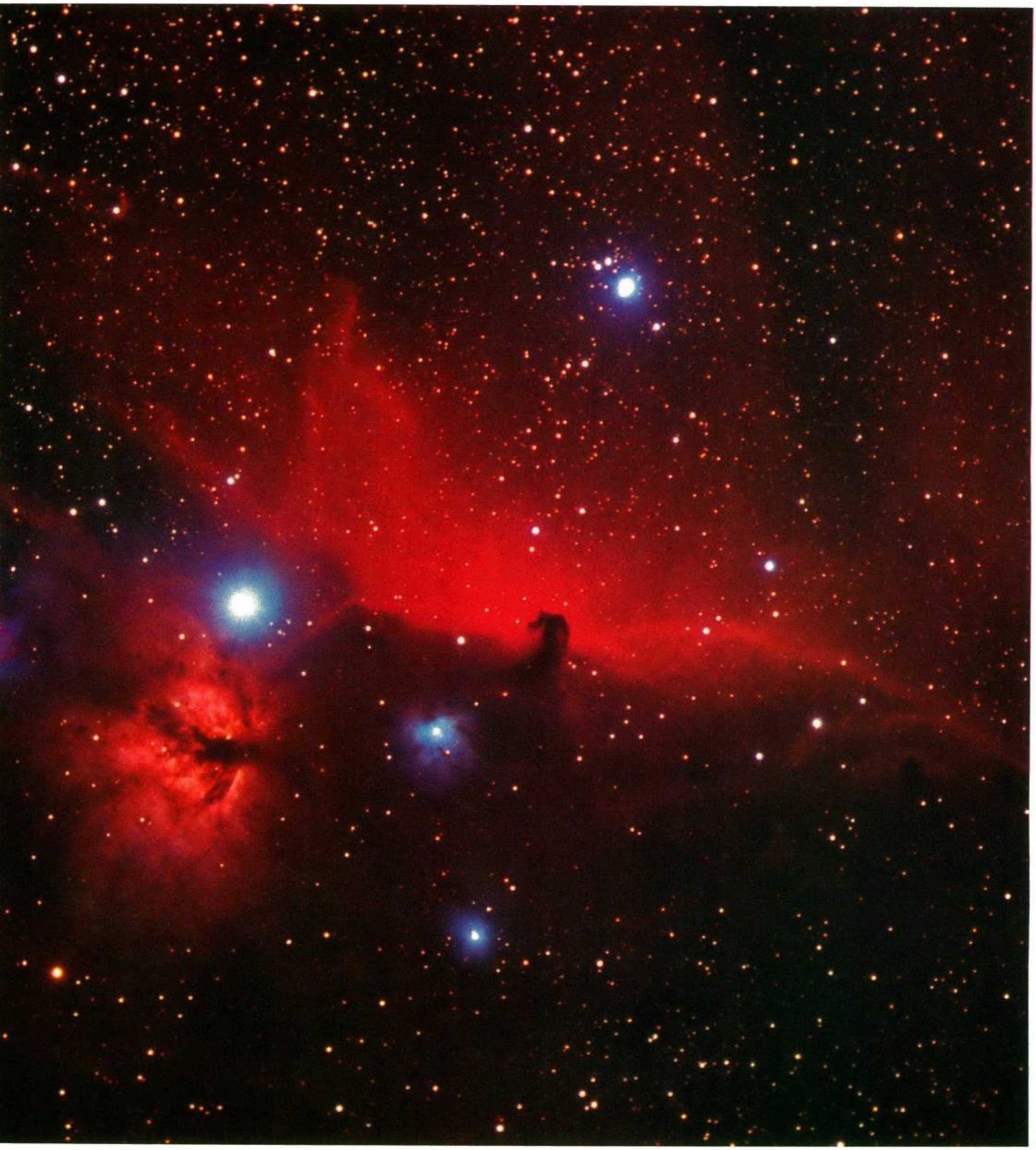
(85mm lens at f/4, Fuji Super HG 400 film, 30-minute exposure taken November 17, 1998)

Central Cygnus Nebulosity

MICHAEL STECKER

(180mm lens at f/2.8, hypered Tech Pan film, 60-minute exposure)

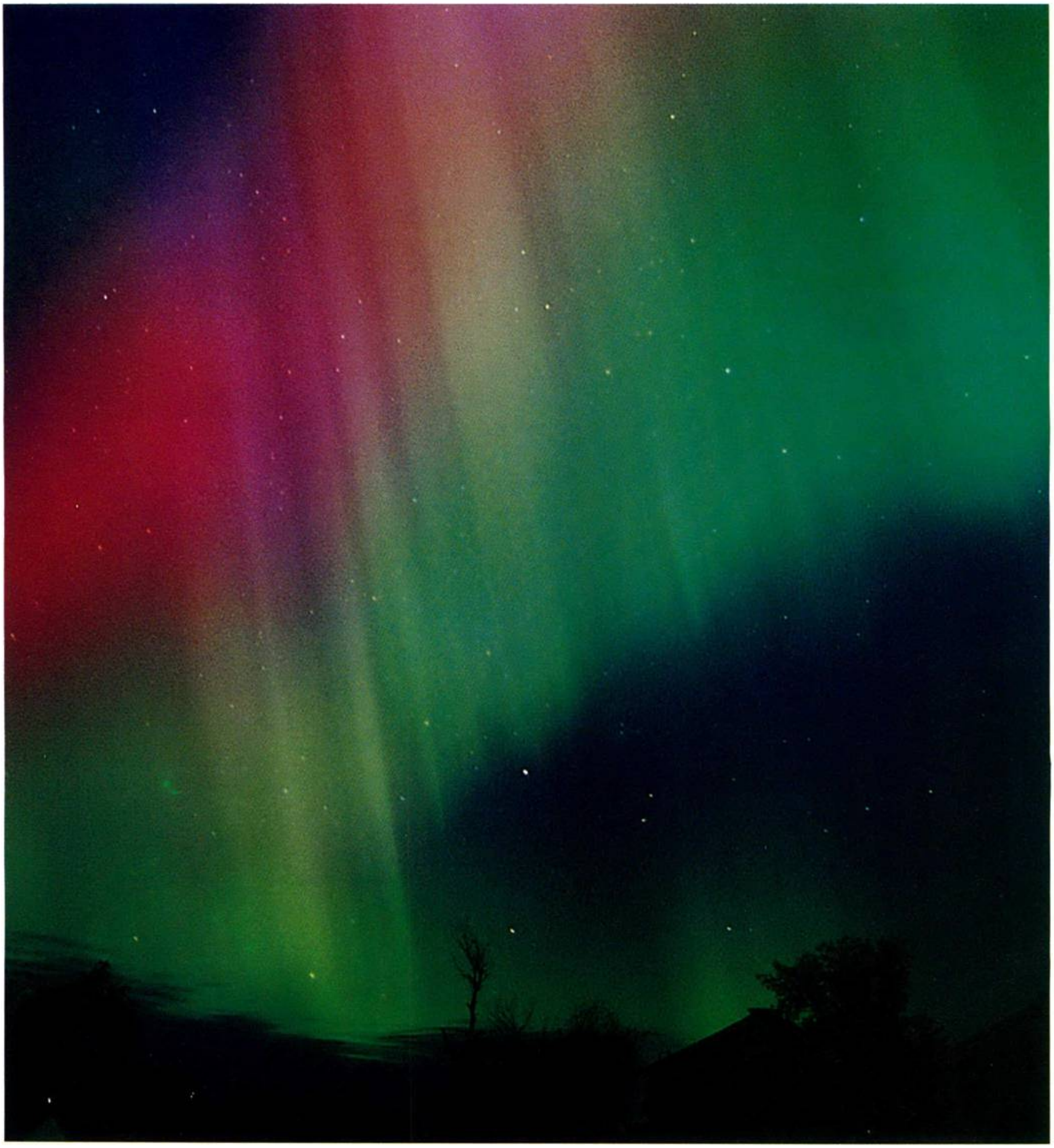




The Horsehead Nebula (B33) in Orion

TONY AND DAPHNE HALLAS

(7-inch f/7 refractor, PPF film, 120-format)



Spectacular Aurora Graces North Dakota Skies

JAY BRAUSCH

(taken at 5 A.M. on September 25, 1998)

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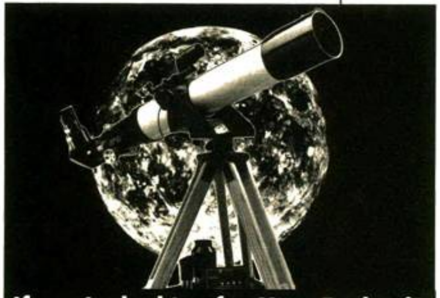

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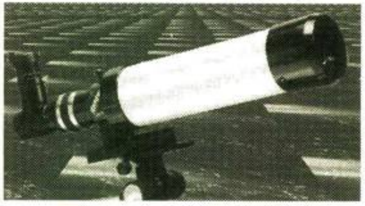

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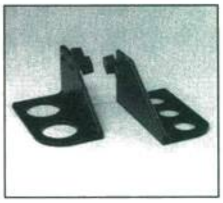

Don't chance your eyepieces rolling off a mount tray. Caddy 'em! So simple, so functional, so neat! The Eyepiece Caddy set holds 3, 1¼" and 2, 2" eyepieces at your fingertips. Fits the yoke arms of any Tele Vue Alt-Az head. Incl. 1¼" inserts for 2" holes.

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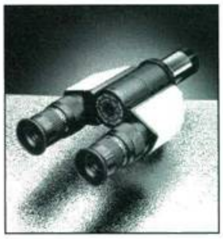
Twice is Nice for Newtonians



Bino Vue now has an optimized 2x, parfocal image amplifier for three times more field area. Great for all scope types. Bino Vue has no focus shift during inter-ocular adjustment, large multi-coated prisms and Tele Vue quality.

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Star-hop across the sky with Starbeam and Qwik-Point "red-dot" finders. Starbeam features a large 40mm lens, variable brightness, elegant design and all metal construction. Qwik-Point offers day & variable night brightness, light weight & exceptional value.

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50°- Mr. P Would be Proud

Preferred Plössl in S&T comparison review. Fully multi-coated, patented Nagler design. 55, 40, 32, 25, 20, 15, 11, 8mm

NEW! TELE-POD

Earth & Sky Travel Tripod

This 7lb. tripod is for those on the go! Perfect for Pronto and Ranger. We've created a new yoke & cradle head with built-in azimuth bearing, and combined it with aluminum legs for a great mix of stability and portability. The Alt/Az head also fits any standard photo tripod.

24mm - 8mm *ZoOOM*

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For the past 20 years Tele Vue has proudly offered quality astronomical equipment to amateur astronomers. Design revolutions: "Nagler" eyepieces, true Multi-Purpose telescopes and now Powermate to name a few, combine with exceptional quality control and knowledgeable service to create an ownership experience "...even better than you imagined."

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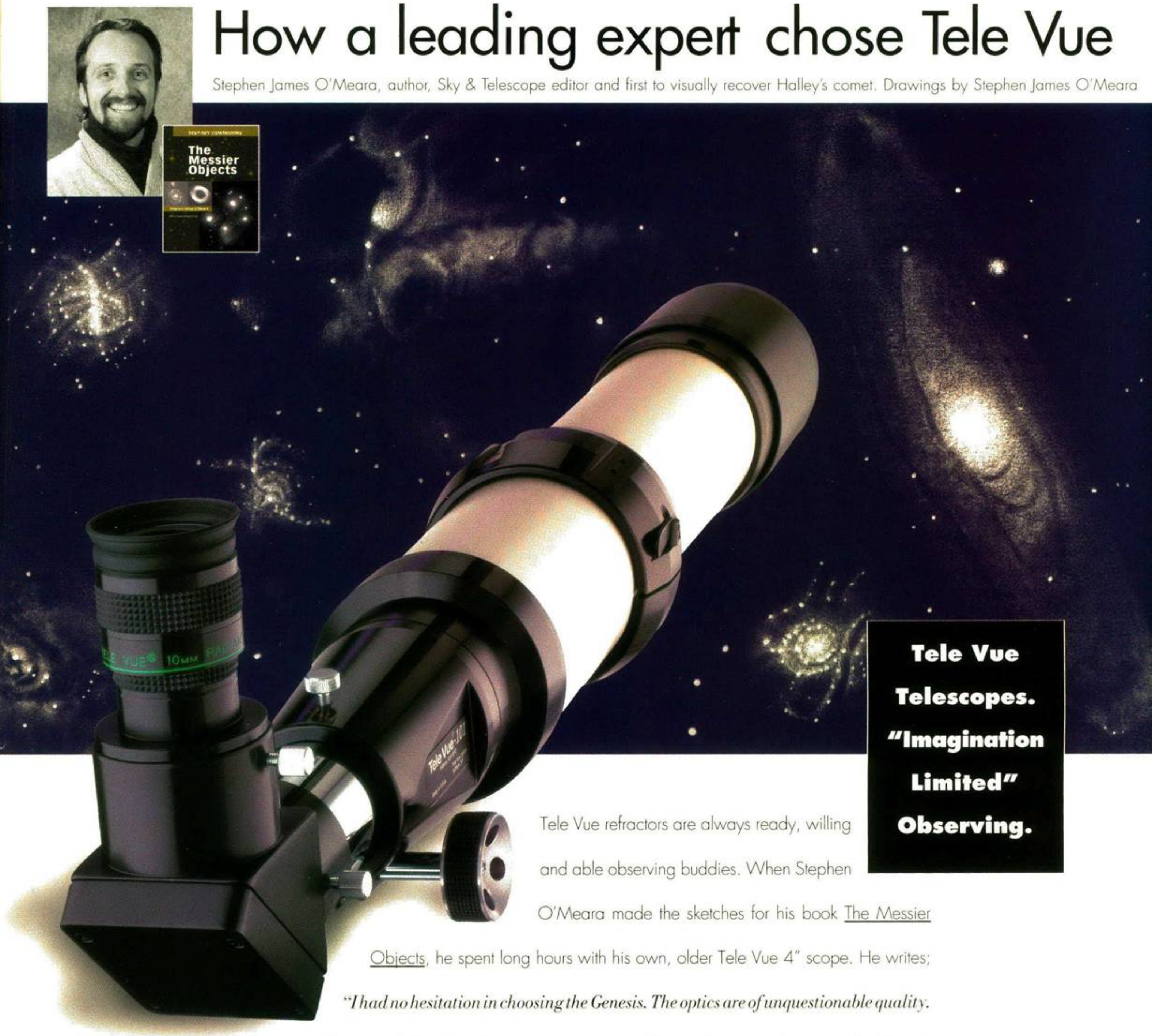
How a leading expert chose Tele Vue

Stephen James O'Meara, author, Sky & Telescope editor and first to visually recover Halley's comet. Drawings by Stephen James O'Meara



Tele Vue Telescopes. "Imagination Limited" Observing.

Tele Vue refractors are always ready, willing and able observing buddies. When Stephen O'Meara made the sketches for his book The Messier Objects, he spent long hours with his own, older Tele Vue 4" scope. He writes; *"I had no hesitation in choosing the Genesis. The optics are of unquestionable quality. When coupled with Tele Vue eyepieces (equally revolutionary designs), the Genesis transcends the traditional limitations of long-focus and rich-field refractors, combining the best qualities of both. Genesis and I met serendipitously under dark Texas skies, where I realized its quality and potential. The rest is history."* Stephen discovered a primary virtue of all Tele Vue scopes - versatile performance. Take one along for "imagination limited" observing.

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Tele Vue 85: APO, f/7.0

Pronto: 70mm ED, f/6.8

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Region of the Lagoon Nebula (M8) and Trifid Nebula (M20) in Sagittarius. Photograph by Jason Ware with the Meade 12" f/2.2 Schmidt Camera. A composite of two 17-minute, CCD-autoguided exposures on Kodak Ektar 25 film. The 2.3° x 2.3° area shown above represents less than one-fourth of the actual 4.3° x 5.4° sky area imaged by the Meade Schmidt Camera.

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